Point Mugu Sea Range
Marine Mammal Technical Report

by

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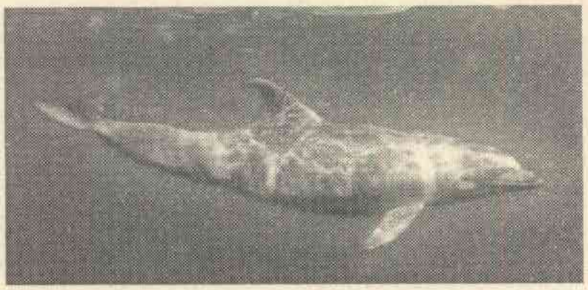
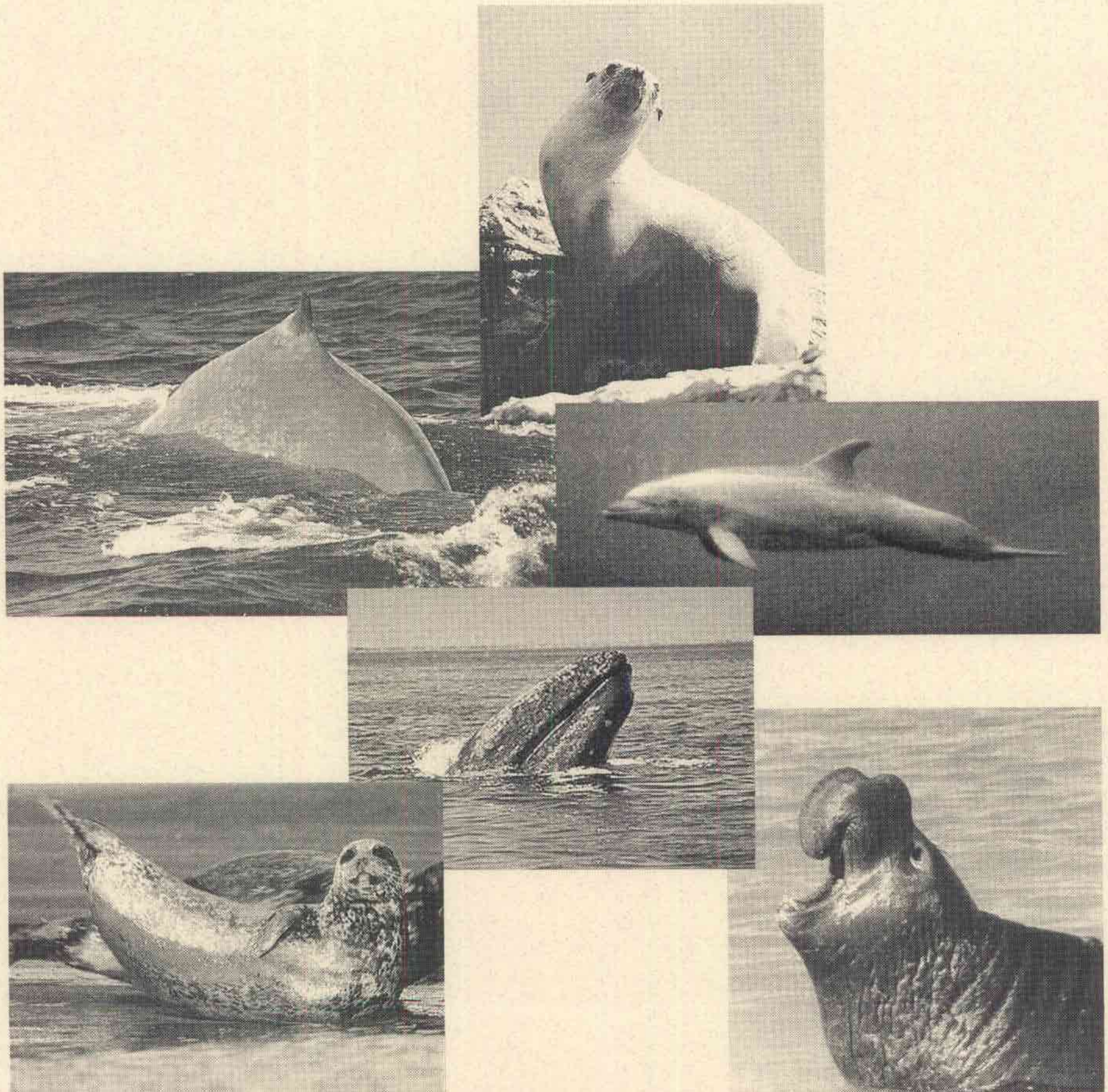


Introduction



INTRODUCTION

This document provides background information on marine mammals compiled while preparing the Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) for the Point Mugu Sea Range. The Point Mugu Sea Range is located off the coast of southern California. It is operated by the Naval Air Warfare Center Weapons Division (NAWCWPNS) Point Mugu.

The EIS/OEIS assesses potential environmental impacts associated with current and proposed activities conducted by the U.S. Navy on the Point Mugu Sea Range. The EIS/OEIS covers 14 disciplines and has been prepared for broad distribution. Thus, in the EIS/OEIS it was necessary to provide only brief descriptions of the marine mammal populations that are present, and to summarize the assessments of potential impacts of the various alternative actions on these populations.

The present document provides more detailed information that will be of interest to those in the marine mammal field and to others who wish to review the technical methodology and data used to estimate impacts on marine mammals. This document contains two separate, self-contained chapters, one describing the marine mammal populations of the Point Mugu Sea Range, and the other assessing the impacts of current and proposed Navy activities on the Sea Range.

To facilitate cross-referencing between this Technical Report and the EIS/OEIS, the organization and chapter numbering system in the EIS/OEIS have been maintained in the technical report.

The first chapter is "Descriptions of Marine Mammal Populations." It corresponds to Chapter 3.7 in the EIS/OEIS. As compared with the EIS/OEIS, it provides much greater detail on the life histories, distributions, and numbers of marine mammals that occur in the Point Mugu Sea Range. Much of this information has been obtained from the published literature. In addition, some of the researchers active in this area provided access to unpublished data and/or advance copies of forthcoming publications.

The first chapter also includes the results of new analyses of existing aerial and ship survey data concerning the distribution and numbers of marine mammals at sea within the Point Mugu Sea Range. As part of the work on the EIS/OEIS, original aerial and ship survey data were obtained, mapped, and analyzed. Many of these data have been summarized in previous reports and publications, but these data have not previously been drawn together to provide a unified account of the marine mammals of the Sea Range. Most of the relevant data came from two sources: (1) The National Marine Fisheries Service, Southwest Fisheries Science Center (NMFS/SWFSC), at La Jolla, California, provided the results of several of their recent aerial and ship-based surveys in digital form. (2) The extensive year-round surveys funded by the Minerals Management Service (formerly Bureau of Land Management) during 1975-78 and 1980-83 (MMS/BLM) were also available in digital form.

During the interval between the MMS/BLM and recent NMFS/SWFSC surveys there have been changes in the numbers and distribution of some species of marine mammals in the Point Mugu Sea Range. Therefore, the analyses (especially for cetaceans) considered primarily the recent NMFS/SWFSC data. However, the larger MMS/BLM data set provided important information on the relative seasonal abundance of cetaceans, and provided most of the available data on the seasonal distribution and numbers of pinnipeds at sea within the Sea Range.

One of the main purposes for the new analyses of NMFS/SWFSC and MMS/BLM data was to provide quantitative estimates of the numbers of marine mammals that might be exposed by Navy activities at sea within the Point Mugu Sea Range. The aerial and ship survey data had not previously been presented or

analyzed in a manner that would permit such estimates. Appendix A, "Estimating Densities and Numbers of Marine Mammals at Sea on the Point Mugu Sea Range," provides a brief description of the complex analyses that were used to make these quantitative estimates. NMFS/SWFSC provided very helpful advice and assistance throughout this project regarding appropriate methods for analysis, presentation, and interpretation of the data.

The second chapter of this Technical Report is "Biological Consequences for Marine Mammals." It corresponds to Chapter 4.7 in the EIS/OEIS. As compared with the EIS/OEIS, it provides a more detailed review of marine mammal hearing in air and in water, and descriptions of methodologies used to estimate impacts of noise, other activities, debris, and contaminants on marine mammals. Pinnipeds, mysticetes, and odontocetes are examined separately because of their different hearing capabilities and behavioral traits that make them differentially susceptible to different activities. Sea otters are also considered separately where relevant. (There is an experimental translocated population of sea otters at San Nicolas Island.) Chapter 4.7 provides a description of the factors that were considered in assessing the effects of various military activities on these three groups of marine mammals. It also provides information on the noise level contours associated with various Navy activities, and a summary of the numbers of marine mammals that might be affected by these noise sources based on the marine mammal distribution and density data provided in the first chapter.

ACRONYMS

ADL	Aerobic Dive Limit
A-SEL	A-weighted Sound Exposure Level
BLM	Bureau of Land Management (U.S. Dept. of Interior)
BPI	Boost Phase Intercept
CI	Confidence Interval
CIWS	Close-In Weapon System
CV	Coefficient of Variation (= standard error of estimate divided by estimate)
dBA	A-weighted sound pressure level, referenced to 20 microPascals for in-air sounds
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FLEETEX	Fleet Exercise
HERP	Hazards of Electromagnetic Radiation to Personnel
IWC	International Whaling Commission
JATO	Jet Assisted Take-Off
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service (U.S. Dept. of Interior)
μPa	microPascal – a unit of pressure used in measuring sound levels
NAS	Naval Air Station
NAWCWPNS	Naval Air Warfare Center, Weapons Division
NAWS	Naval Air Weapons Station
NEPA	National Environmental Policy Act
NM	Nautical Mile (=1.15 statute miles or 1.853 kilometers)
NMFS	National Marine Fisheries Service (U.S. Dept. of Commerce)
NMML	National Marine Mammal Laboratory, NMFS (Seattle, WA)
OEIS	Overseas Environmental Impact Statement
OSPR	Oil Spill Prevention and Response
OSTR	Outer Sea Test Range (part of Point Mugu Sea Range)
POP	Platforms of Opportunity Program (a NMFS database)
PTS	Permanent Threshold Shift
rms	Root Mean Square (a type of average)
SCB	Southern California Bight
SD	Standard Deviation
SE	Standard Error
SEL	Sound Exposure Level – equivalent level if transient sound was steady for a 1-second period
SR	Sea Range
SWFSC	Southwest Fisheries Science Center, NMFS (La Jolla, CA)
TMD	Theater Missile Defense
TDR	Time Depth Recorder
TTS	Temporary Threshold Shift
USFWS	U.S. Fish and Wildlife Service (U.S. Dept. of Interior)

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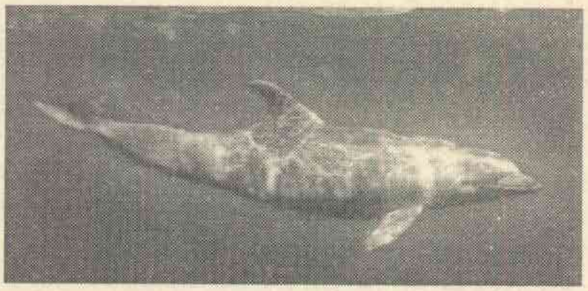

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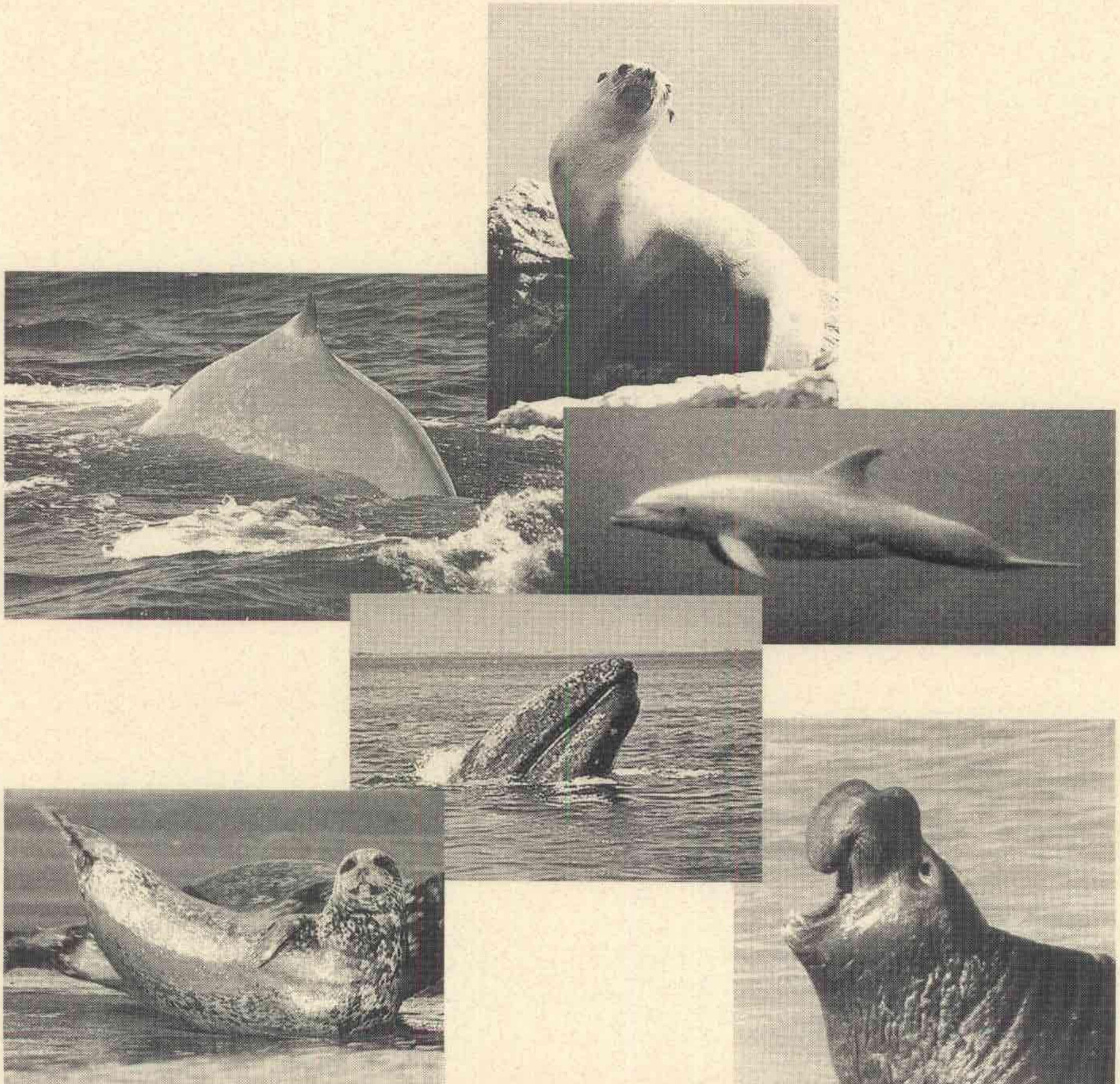

POINT MUGU SEA RANGE
MARINE MAMMAL TECHNICAL REPORT

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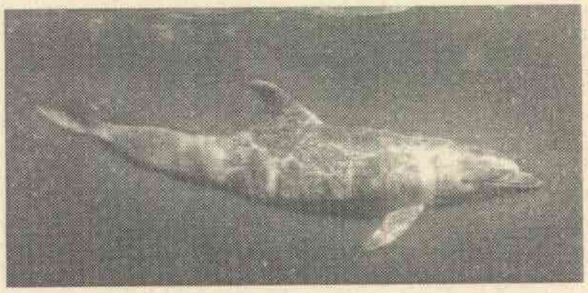
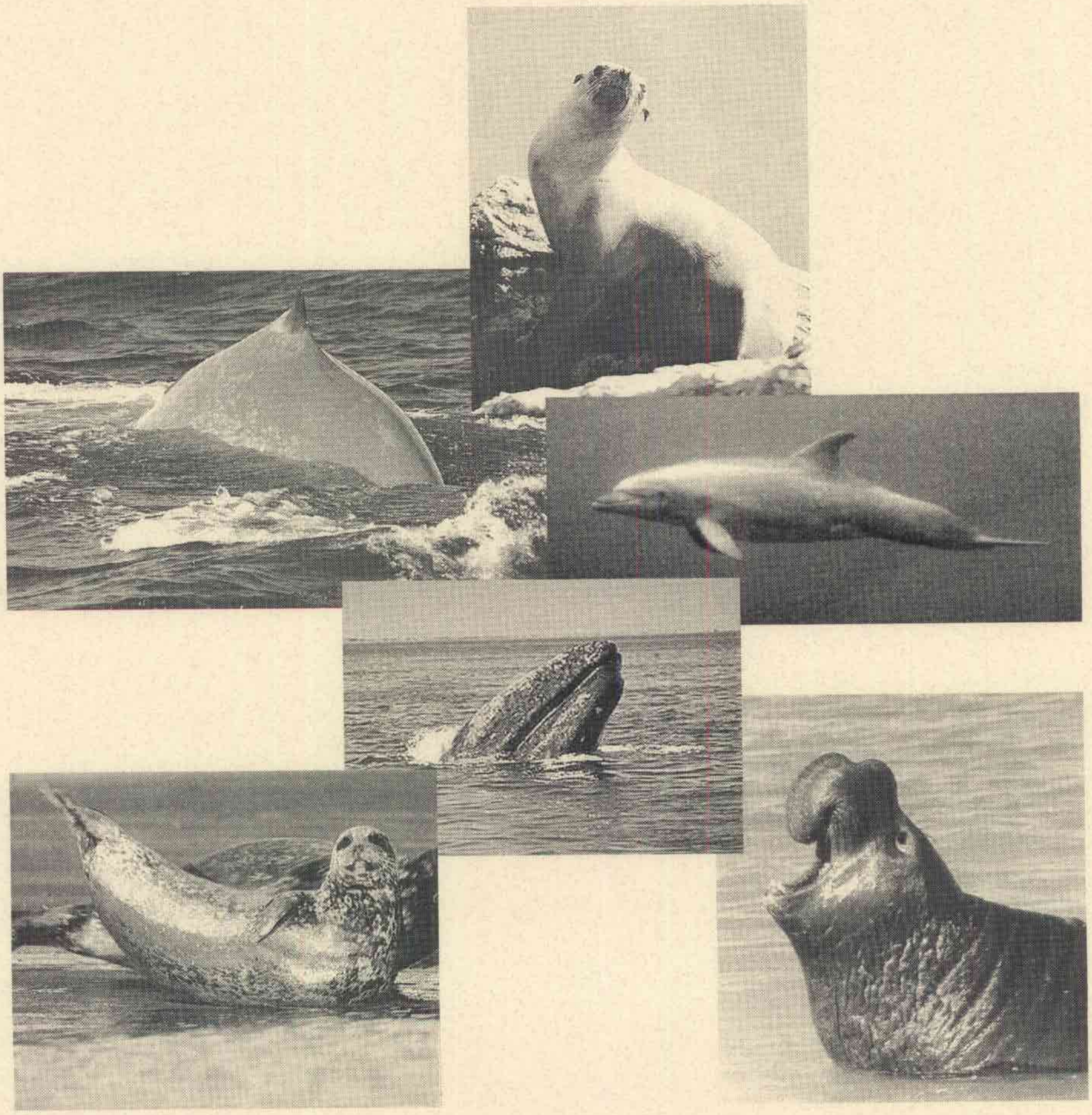


3.7 Descriptions of Marine Mammal Populations



3.7 Descriptions of Marine Mammal Populations

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Dr. Michael L. Bonnell, working as a consultant to LGL Ltd., summarized some of the Minerals Management Service data from the late 1970s and early 1980s into a format suitable for use in the maps and analyses included in this report. He also provided survey data from the initial stages of the ongoing OSPR (Oil Spill Prevention and Response) study.

Dr. Don Croll of the University of California, Santa Cruz, provided unpublished data on the diving behavior of blue whales.

Nathalie Patenaude of LGL assisted in the early stages of the literature review, and Kathleen Hester assisted with the layout of some of the Figures.

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3.7 MARINE MAMMALS

3.7.1 Introduction

3.7.1.1 Definition of Resource

Marine mammals addressed within this EIS/OEIS include members of three distinct taxa: *Cetacea*, which includes whales, dolphins, and porpoises; *Pinnipedia*, which includes seals and sea lions (the walrus is also included in this order but is not relevant to this EIS/OEIS); and *Carnivora*, which includes a member of the *Mustelidae* family, the sea otter. Cetaceans–the whales, dolphins, and porpoises–spend their lives entirely at sea. Pinnipeds–the seals and sea lions–hunt and feed exclusively in the ocean; however, the species occurring in the Point Mugu Sea Range come ashore to rest, mate, and bear young. Although most mustelids (a family which includes otters, weasels, skunks, and wolverines) are terrestrial, sea otters regularly swim and feed in the ocean.

Cetaceans

At least 34 species of cetaceans have been identified from sightings or strandings in the Southern California Bight (SCB) (Bonnell and Dailey 1993; Table 3.7-1). These include 26 species of toothed whales (odontocetes) and 8 species of baleen whales (mysticetes). At least 9 species generally can be found in the study area in moderate or high numbers either year-round or during annual migrations into or through the area. These include the Dall's porpoise (*Phocoenoides dalli*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), Risso's dolphin (*Grampus griseus*), bottlenose dolphin (*Tursiops truncatus*), short-beaked and long-beaked common dolphins (*Delphinus delphis* and *D. capensis*), northern right whale dolphin (*Lissodelphis borealis*), Cuvier's beaked whale (*Ziphius cavirostris*), and gray whale (*Eschrichtius robustus*). Other species are represented by small numbers, moderate numbers during part of the year, occasional sightings, or strandings.

Several species of cetaceans occurring on the Sea Range are listed as **endangered** or **threatened**. Most endangered mysticetes that occur in California waters were once commercially hunted to the point that their populations were severely depleted. The northern right whale (*Eubalaena glacialis*), humpback whale (*Megaptera novaeangliae*), and the blue, fin and sei whales (*Balaenoptera musculus, B. physalus*, and *B. borealis*, respectively) are currently federally listed as endangered species and protected by the Endangered Species Act (ESA) (16 U.S.C. § 1531) (Braham 1991). Gray whales have recently been removed from the endangered list due to an increase in population numbers (NMFS 1993).

Several of the "endangered" species have also been listed as "**strategic stocks**" under the MMPA. The specific definition of a "strategic stock" is complex, but in general it is a stock in which human activities may be having a deleterious effect on the population and may not be sustainable. The stocks of blue, fin, sei, and humpback whales occurring off California are considered "strategic" (Barlow et al. 1997). In addition, the California stocks of the short-finned pilot whale (*Globicephala macrorhynchus*) and sperm whale (*Physeter macrocephalus*) have been designated as "strategic." The stocks of minke whales (*Balaenoptera acutorostrata*) and mesoplodont beaked whales (collectively) off the coast of California/Oregon/Washington have recently been reclassified as non-strategic (NMFS 1998; Barlow et al. 1998).

In addition to the special designations summarized above, all marine mammals are protected by the Marine Mammal Protection Act (MMPA 1972, amended 1994 - 16 U.S.C. § 1431 *et seq.*).

Table 3.7-1. Summary of information on cetaceans that might be encountered in the Point Mugu Sea Range.

Species	Status	California Stock Size (CV)*	Abundance in Sea Range	Population Trend[1]	Seasonality	Habitat Preference
Harbor porpoise (*Phocoena phocoena*)	** Recommended as strategic	13,370 [4,120 (0.22)[2] + 9,250 (0.23)[2]]	Rare	Evidence of decline 1986-1995; not statistically significant	Winter? Mainly inshore of Sea Range at other seasons	Coastal, temperate waters, mainly north of Point Conception
Dall's porpoise (*Phocoenoides dalli*)	**	47,661 (0.40)[3]	Common	N.A.	Year-round resident, peak numbers in autumn/winter. Low numbers in summer	Continental shelf, slope, and offshore; water <17°C
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	**	121,693 (0.47)[4]	Common	N.A.	Year-round resident with N-S movements to colder-water areas in late spring and summer	Continental shelf, slope and offshore; prefers deep waters
Risso's dolphin (*Grampus griseus*)	**	32,376 (0.46)[4]	Common	N.A. Increased sightings during last 20 years may reflect increased survey effort	Year-round resident, peak in winter. Low numbers in summer	Mostly offshore, recently over continental shelf
Bottlenose dolphin (*Tursiops truncatus*) coastal	**	140 (CV 0.05)[1]	Rare	N.A.	Year-round resident of coastal areas east of SR	Within 0.5 NM of shore
Bottlenose dolphin (*Tursiops truncatus*) offshore	**	2,555 (0.36)[1]	Uncommon; mostly SE of SR	N.A.	Year-round resident, no seasonal peak	Continental shelf, slope, and offshore waters
Short-beaked common dolphin (*Delphinus delphis*)	**	372,425 (0.22)[3]	Common and seasonally abundant	Increasing (due to changes in distribution?)	Year-round resident in southern SR; summer resident in northern SR; lower numbers in summer	Coast to 300 NM or farther from shore
Long-beaked common dolphin (*Delphinus capensis*)	**	8,980 (0.64)[3]	Uncommon	Probably increasing (due to changes in distribution?)	Year-round resident, peak numbers in summer	Coast to 50 NM from shore

Table 3.7-1. Summary of information on cetaceans that might be encountered in the Point Mugu Sea Range (continued).

Species	Status	California Stock Size (CV)*	Abundance in Sea Range	Population Trend[1]	Seasonality	Habitat Preference
Northern right whale dolphin (*Lissodelphis borealis*)	**	21,332 (0.43)[4]	Common	N.A.	Resident in SR in winter and spring, peak numbers in winter. Few in southern SR in summer	Continental slope; water 8-19°C
Short-finned pilot whale (*Globicephala macrorhynchus*)	** Strategic	1,004 (0.37)[3]	Common before 1982, uncommon in SE part of SR now	A population shift from the SR occurred after the 1982 El Nino, some animals have returned	Year-round resident	Offshore and shallow waters
Cuvier's beaked whale (*Ziphius cavirostris*)	**	9,163 (0.52)	Uncommon	N.A.	Unknown, but catches by whalers near the SR were Oct-Jan	Pelagic
Sperm whale (*Physeter macrocephalus*)	** Endangered, depleted, and strategic	1,231 (0.39)[3] underestimated	Uncommon	Stable in coastal waters 1979-1991	Most common in autumn and winter but seasonal abundance varies	Usually pelagic; water >15°C; inshore when squid are abundant
Striped dolphin (*Stenella coeruleoalba*)	**	24,910 (0.31)[3]	Occasional visitor from offshore	Probable increase over the last decade	Probably summer and autumn	100-300 NM or more offshore
Spinner dolphin (*Stenella longirostris*)	**	N.A.	Rare	N.A.	Possible in summer	Warm nearshore waters
Spotted dolphin (*Stenella attenuata*)	**	N.A.	Rare	N.A.	Possible in summer	Pelagic, tropical and temperate waters
Rough-toothed dolphin (*Steno bredanensis*)	**	N.A.	Rare	N.A.	Possible in summer	Warm nearshore waters
Killer whale (*Orcinus orca*)	**	747 (0.71)[3]	Uncommon	N.A.	Probable year-round resident	Widely distributed
False killer whale (*Pseudorca crassidens*)	**	N.A.	Rare	N.A.	Possible in summer	Pelagic, tropical and sub-tropical waters

Table 3.7-1. Summary of information on cetaceans that might be encountered in the Point Mugu Sea Range (continued).

Species	Status	California Stock Size (CV)*	Abundance in Sea Range	Population Trend[1]	Seasonality	Habitat Preference
Baird's beaked whale (*Berardius bairdii*)	**	380 (0.53) [3] probably biased downwards	Rare	N.A.	Present late spring to early autumn	Continental slope and pelagic
Blainville's beaked whale (*Mesoplodon densirostris*)	**	728 (2.03) [3]	Rare	N.A.	Unknown	Pelagic
Other Mesoplodont beaked whales (Hector's, Stejneger's, Gingko-toothed, Hubbs') (*Mesoplodon* spp.)	**	1,378 (0.58) [3]	Rare	N.A.	Unknown	Pelagic
Pygmy sperm whale (*Kogia breviceps*)	**	3,145 (0.54) to 4,036 (incl. poss. dwarf sperm whales)	Rare	N.A.	Possible year round	Seaward of continental shelf
Dwarf sperm whale (*Kogia simus*)	**	Fewer than 891 (2.04) [1] (incl. poss. pygmy sperm whales)	Possible visitor	N.A.	Possible in summer	Continental shelf
Northern right whale (*Eubalaena glacialis*)	** Endangered	about 200 [5]	Rare	Near extinction	Sightings from Mar-May	Unknown, recent sightings have been nearshore
Humpback whale (*Megaptera novaeangliae*)	** Endangered, depleted, and strategic	597 (0.07)[7]	Uncommon	Possible increase 1979-1993	Migratory during spring and autumn; feeding in summer	Nearshore waters
Gray whale (*Eschrichtius robustus*)	** Delisted in 1994	23,109 (CV=0.074)[6]	Most of population passes through or east of SR during migration	Increasing	Southbound migration Dec-Feb, peaking in Jan; northbound Feb-May, peaking in March	Mostly coastal but offshore routes are used near the Channel Islands
Blue whale (*Balaenoptera musculus*)	** Endangered, depleted, and strategic	1,785 (0.24)[3]	Uncommon	Increase 1979-1991, possibly in part due to change in distribution	Migratory, resident Jun-November	Primarily offshore

Table 3.7-1. Summary of information on cetaceans that might be encountered in the Point Mugu Sea Range (continued).

Species	Status	California Stock Size (CV)*	Abundance in Sea Range	Population Trend[1]	Seasonality	Habitat Preference
Fin whale (*Balaenoptera physalus*)	** Endangered, depleted, and strategic	933 (0.27)[3]	Uncommon	Possible increase from 1979-1993	A few present year-round in southern part of SR. Peak in summer when present throughout SR	Continental slope and offshore waters
Sei whale (*Balaenoptera borealis*)	** Endangered, depleted, and strategic	A few to several 10's	Rare	N.A. but North Pacific population expected to have grown since mid-1960	Migratory. Possible in spring, likely in summer	Primarily offshore, temperate waters
Bryde's whale (*Balaenoptera edeni*)	**	24 (2.0)	Rare	N.A.	Summer?	Tropical to subtropical waters
Minke whale (*Balaenoptera acutorostrata*)	**	201 (0.65)[3]	Uncommon, primarily in SE part of SR	N.A.	Migratory, peak in spring and summer, a few are present year-round	Primarily over continental shelf but some offshore

* CV (coefficient of variation) is a measure of a number's variability. The larger the CV, the higher the variability.
** Protected under the Marine Mammal Protection Act.
SR – Sea Range.
N.A. – Not available.
[1] Barlow et al. (1997); [2] Central and Northern California stocks (Barlow and Forney 1994); [3] Barlow and Gerrodette (1996); [4] Forney et al. (1995); [5] Braham and Rice (1984); [6] Small and DeMaster (1995); [7] Calambokidis and Steiger (1994).

Overall, a comparison of cetacean abundance in 1979/80 vs. 1991 indicated that numbers of mysticetes and odontocetes have increased in offshore California waters over the 12-year period. However, this is not so for the harbor porpoise (*Phocoena phocoena*) and the short-finned pilot whale, which appear to have decreased in numbers (Barlow 1994, 1995; Forney et al. 1995). The status of cetacean stocks and their abundance estimates for California are summarized in Table 3.7-1 from marine mammal stock assessments prepared by Barlow et al. (1997).

Pinnipeds

Six species of pinnipeds occur in the Point Mugu Sea Range (Table 3.7-2). The four most abundant species are the harbor seal (*Phoca vitulina*), northern elephant seal (*Mirounga angustirostris*), California sea lion (*Zalophus californianus*), and northern fur seal (*Callorhinus ursinus*). These four species breed on land within the Sea Range. The overall abundance of these species increased rapidly on the Channel Islands between the end of commercial exploitation in the 1920s and the mid-1980s. The growth rates of populations of some species appear to have declined after the mid-1980s, and some recent survey data suggest that localized populations of some species may be declining. These declines may be due either to interspecific competition or to population numbers having exceeded the carrying capacity of the environment (Stewart et al. 1993; Hanan 1996). However, most populations continue to increase rapidly, and in some cases seals have recently occupied new rookeries and haul-out areas. These four pinniped species are not listed as endangered or threatened under the ESA (Barlow et al. 1997).

Two of the six pinniped species on the Sea Range are less common. The Guadalupe fur seal (*Arctocephalus townsendi*) is an occasional visitor to the Channel Islands and breeds only on Guadalupe Island, Mexico, which is approximately 250 NM (463 kilometers) south of the Sea Range. The Steller sea lion (*Eumetopias jubatus*) was once abundant in these waters, but numbers have declined rapidly since 1938. No adult Steller sea lions have been sighted since 1983 (NMFS 1992). The Guadalupe fur seal and the Steller sea lion are federally designated as threatened and depleted species and their stocks are considered to be strategic stocks. The Guadalupe fur seal is listed as threatened and fully protected by California state legislation.

Populations of seals may be impacted by changes in the distribution and abundance of their prey species. The El Niño event of 1983 temporarily reduced resources for most pinnipeds in the Channel Islands (Trillmich et al. 1991). As a consequence, pinnipeds spent more time at sea searching for prey (Stewart and Yochem 1991), and there was a decline in the number of pups and adults counted at rookeries. However, overall population declines may have been less pronounced than suggested by shore counts. Specific information about population changes during the 1998 El Niño event is not yet available.

Sea Otter

The southern sea otter (*Enhydra lutris nereis*) occurs along the coast of central California between Point Año Nuevo and Purisima Point, and a small experimental population has been translocated to San Nicolas Island. Sea otters were heavily harvested during the 18th and 19th centuries and were nearly exterminated from California waters. The existing population is believed to have expanded primarily from a remnant population at Bixby Creek along the coast of southern Monterey County (Leatherwood et al. 1978). These sea otters were protected in 1911, and the population has slowly increased and expanded its range. Aside from the small translocated population at San Nicolas Island, few sea otters are expected to occur within the Point Mugu Sea Range because of their preference for relatively shallow (~66 feet [20 meters] deep) coastal waters. (The Sea Range does not include any of the mainland

Table 3.7-2. Summary of information on pinnipeds and sea otters that might be encountered in the Point Mugu Sea Range.

Pinnipeds	Status	California stock size	Abundance in study area	Population trend	Typical depth of dive (feet)	Maximum depth of dive (feet)	Average dive duration	Interdive surface interval	Foraging locations	Common prey
Harbor seal (*Phoca vitulina richardsi*)	*	30,293[1]	3,600 - 4,600[17,18]	+1.9%/yr in study area; +3.5%/yr in California	33 - 130 nursing females; 260 - 390 others	1,200 (females), 1,640 (males)[13]	3-7 min	2-3 min[2]	most <2.7 NM from shore; occasionally to 27 NM	rockfish, spotted cuskeel, octopus, plainfin midshipman, shiner surfperch
Northern elephant seal (*Mirounga angustirostris*)	*	84,000[1]	71,000	+8.3%/yr; may have slowed or declined since 1994	492 - 2,625; night dives shallower than day dives[4]	5,140 (females), 5,190 (males)[3]	23.6 min (females); 23.1 min (males)[4]	2-3 min	40° and 45° N lat. for females, further N for males[3]	squid, Pacific whiting, pelagic red crab, octopus, hake, ratfish, rockfish, angel and blue shark, stingray[5,12,20]
California sea lion (*Zalophus californianus californianus*)	*	167,000 - 188,000[1]	159,000 - 179,000 >95% of US stock	+8.3%/yr	328 - 1,150 (102 - 322, females)[6]	900 (females) 1,590 (males)[6]	3-9 min (1-1.9 min, females)[6]	0.7-3.1 min[6]	0.5 - 54 NM from rookery, mean 29.3 NM; mean depth 1,060 feet[8,11]	northern anchovy, Pacific whiting, market squid, nail squid, red octopus, rockfish, jack mackerel[7]
Steller sea lion (*Eumetopias jubatus*)	* threatened	2,000 in 1989[22]	rare	declining						
Guadalupe fur seal (*Arctocephalus townsendi*)	* threatened	7,408 for Guadalupe Is. in 1993[23]	Occasional[15]	+13.7%/yr	56[19]	270[19]	2.6 min[19]	2.0 min[19]	up to 240 NM from rookery[19]	unknown, but includes squid[24]
Northern fur seal (*Callorhinus ursinus*)	*	10,036[1]	10,036	+25%/yr since 1983	223[10]	755[10]	2.6 min[10]		0.5 - 74 NM from San Miguel, mean 39 NM, mean water depth 3,060 feet; 92% forage NW of San Miguel[11]	northern anchovy, lanternfish, Pacific whiting, market squid, nail squid, Pacific saury[9]
Fissiped										
Southern sea otter (*Enhydra lutris nereis*)	* threatened	2,377[24]	17[24]	+5-7%/yr in California[24]	66[24]		1.23 min	0.43 - 2.58 min	rocky coastline with kelp beds; 66 feet deep (max. 328 feet)[24]	mussels, clams, abalone, sea urchins, sea stars[24]

*Protected under the Marine Mammal Protection Act.
[1]Barlow et al. (1997); [2]Stewart and Yochem (1994); [3]Stewart and DeLong (1995); [4]Stewart and DeLong (1993); [5]Condit (1984); [6]Feldkamp et al. (1989); [7]Lowry et al. (1991); [8]Bonnell and Ford (1987); [9]Stroud et al. (1981); [10]lactating females, Reeves et al. (1992); [11]post-partum females on San Miguel, Antonelis et al. (1990); [12]Antonelis et al. 1987; [13]Stewart et al. 1989; [14]DeLong 1982; [15]Seagars 1984; [16] for San Miguel and San Nicolas, Stewart and Yochem 1994; [17]for San Miguel and San Nicolas, Stewart 1984; [18]Stewart and Yochem 1985; [19]Hanan and Besson 1994; [20]Stewart 1989; [21]Bonnell and Dailey 1993; [22]Loughlin et al. 1992; [23]Hanni et al. 1997; [24]USFWS (1996).

coastline.) The information on sea otter distribution and abundance summarized in this report has come from surveys and reports by the U.S. Fish and Wildlife Service and the California Department of Fish and Game.

The southern sea otter is federally listed as **threatened** under the ESA and designated as **depleted** under the MMPA.

3.7.1.2 Regional Setting

The status of populations of cetaceans and pinnipeds that occur on the Sea Range in relation to populations found off the entire California coast is summarized in Tables 3.7.1 and 3.7.2. Most California gray whales migrate through the Sea Range during their northward and southward migrations. Most members of the California populations of the northern elephant seal, California sea lion, and northern fur seal are found within the Sea Range during at least some part(s) of the year. For most other species, the Sea Range constitutes a relatively small portion of the total range, although in some cases numbers within the Sea Range are high at least at certain times of year. Species-by-species details are given in later sections.

3.7.1.3 Region of Influence

The species accounts that follow deal explicitly with species that occur regularly in the study area in moderate to high numbers, or are designated as depleted or part of a strategic stock under the MMPA, or are listed as endangered under the ESA. Marine mammals inhabiting the entire Sea Range and areas between the Sea Range and coast are discussed in this section. Populations and population trends of pinnipeds that haul out on islands, that are not included within the scope of the EIS, are discussed because these data provide the best estimates of populations that could be found in marine waters of the Sea Range.

3.7.1.4 Major Data Sources and Sighting Maps

Sightings of marine mammals at sea within the study area have been described in many reports and publications. However, there is no one document that maps or summarizes the available data from all relevant studies. To supplement the published accounts, several databases of marine mammal sightings during the period from 1975 to the present were used in preparing the descriptions that follow (Table 3.7-3). Marine mammal sighting data were provided in digital format by the following:

- M. Bonnell of Ecological Consulting Inc., Portland, OR (data from BLM/MMS and OSPR surveys, mainly aerial);
- J. Barlow of Southwest Fisheries Science Center, La Jolla, CA (NMFS/SWFSC aerial and ship surveys); and
- S. Mizroch of National Marine Mammal Laboratory, Seattle, WA (NMFS Platforms of Opportunity Program [POP] database).

Table 3.7-3. Databases summarized during preparation of the environmental description.

	Survey Period												Survey		Number of	
Study	J	F	M	A	M	J	J	A	S	O	N	D	Platform	Year	Sightings	References
NMFS/SWFSC Surveys																
1		X	X	X									Aircraft	1991-92	333	Carretta and Forney 1993
2	X	X	X	X	X	X	X	X		X	X	X	Aircraft	1993-94	1096	Carretta et al. 1995
3							X	X	X	X	X		Ship	1991	548	Hill and Barlow 1992
4							X	X	X				Ship	1993	243	Mangels and Gerrodette 1994
MMS Surveys																
5	X	X	X	X	X	X	X	X	X	X	X	X	Aircraft-High Alt.	1975-78, 80-83	1234	Bonnell et al. 1981, 1983; Dohl et al. 1981, 1983
6	X	X	X	X	X	X	X	X	X	X	X	X	Aircraft-Low Alt.	1975-78, 80-83	2573	Bonnell et al. 1981, 1983; Dohl et al. 1981, 1983
7	X	X	X	X	X	X	X	X	X	X	X	X	Ship	1975-78	2372	Bonnell et al. 1981; Dohl et al. 1981
8	X	X		X	X	X	X	X	X	X	X	X	Opportunistic	1975-78, 80-83	740	Bonnell et al. 1981, 1983; Dohl et al. 1981, 1983
Other Surveys																
9	X	X	X	X	X	X	X	X	X	X	X	X	Opportunistic	1958-91	1428	National Marine Mammal Laboratory, Seattle
10	X	X		X	X	X		X		X	X		Aircraft	1995-96	767	M. Bonnell, unpublished data
11					X						X		Aircraft	1992	973	U.S Fish and Wildlife Service
Total															12307	

NAWCWPNS Point Mugu has divided the Sea Range into a set of standard subdivisions referred to as Range Areas. These are shown in Figure 3.7-1. (Range Areas are used for scheduling purposes and do not appear on navigational charts.) Some range areas include not only offshore waters but also waters within 3 NM (5.6 kilometers) of shore. In mapping and tabulating marine mammal sightings from the various databases, we modified the boundaries of some range areas to distinguish areas within 3 NM (5.6 kilometers) of land, where marine mammal abundance is often different from that farther offshore. A further reason for doing this is that the jurisdictional boundaries of the state of California extend to 3 NM (5.6 kilometers) from shore. The range area boundaries that have been altered are shown as red lines in Figure 3.7-1. Range Areas W-289 and 3E, which were primarily nearshore areas around San Miguel, Santa Rosa, and Santa Cruz islands, were expanded to include parts of Range Areas 3F, 4B, 3D, and 5B that were less than 3 NM (5.6 kilometers) from the coasts of the islands. Range Area M3 was expanded to include areas of 4A that were within 3 NM (5.6 kilometers) of San Nicolas Island. Range Area W-290 was reduced to exclude areas within 3 NM (5.6 kilometers) of Santa Catalina and Santa Barbara islands. Range Areas W1 and 3B/W2 were reduced to exclude areas within 3 NM (5.6 kilometers) of Anacapa Island. In addition, we subdivided Range Area W-537 into W-537A, W-537B, and W-537C. Finally, we defined 8 new "off range" areas between the coastline and the Sea Range (Figure 3.7-1).

The 12 NM (22.2 kilometer) limit from land is also shown on Figure 3.7-1. It is the demarcation between territorial waters (closer than 12 NM [22.2 kilometers] from land) and non-territorial waters (farther than 12 NM [22.2 kilometers] from land). Navy activities in territorial waters are subject to National Environmental Policy Act (NEPA) requirements for analyzing environmental impacts. Navy activities in non-territorial waters are subject to Executive Order 12114 procedures.

The range area within which each sighting occurred was determined using MapInfo Professional 4.1. Sightings were mapped by season and study for the most commonly recorded species, for endangered and depleted species, and for species whose stocks are considered to be strategic. The most important sources of data on the distribution and abundance of cetaceans in the Sea Range are described below.

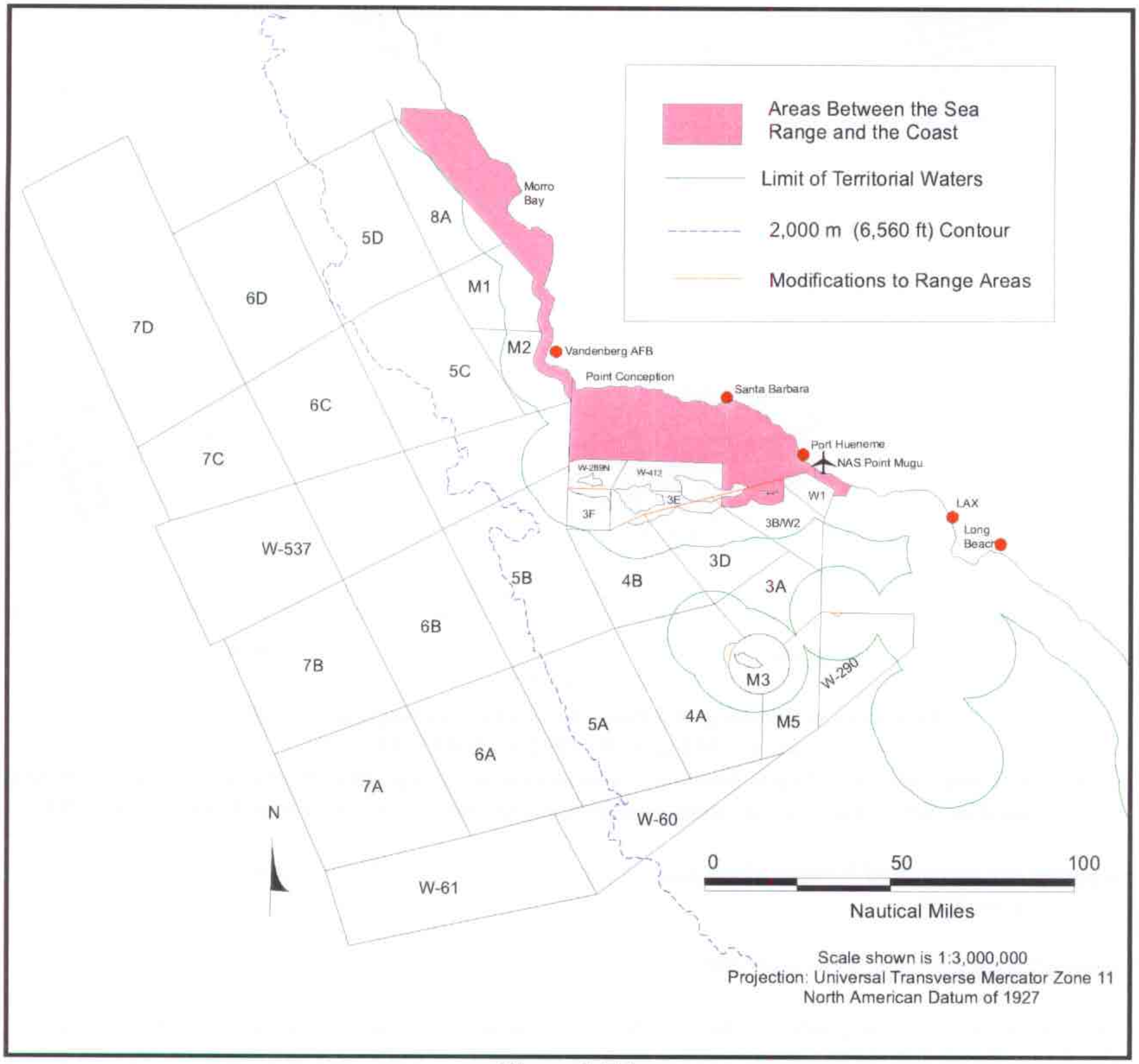


Figure 3.7-1
"Actual" and "modified" boundaries of Range Areas used in the marine mammal section. "Offshore" Range Areas include a small area within 3 NM of shore, the Range Area boundaries are modified to consider waters less than 3 NM from shore as being within adjacent "nearshore" Range Areas. Red lines show the actual boundaries between Range Areas in places where modifications have been made. The green line separates waters within vs. beyond 12 NM from shore. Also shown are areas between the Sea Range and the mainland coast; these are not part of the Sea Range but marine mammal data from those areas have been summarized in this report.

SWFSC Aerial Surveys, 1991 and 1992

Aerial surveys were conducted by NMFS/SWFSC along the coasts of Washington, Oregon and California during February to April of 1991 and 1992. The transects off California are shown in Figure 3.7-2 (study 1 in Table 3.7-3). The survey area extended from the coast offshore to 150 NM (278 kilometers). Each transect was surveyed once during each year. The results of these surveys are

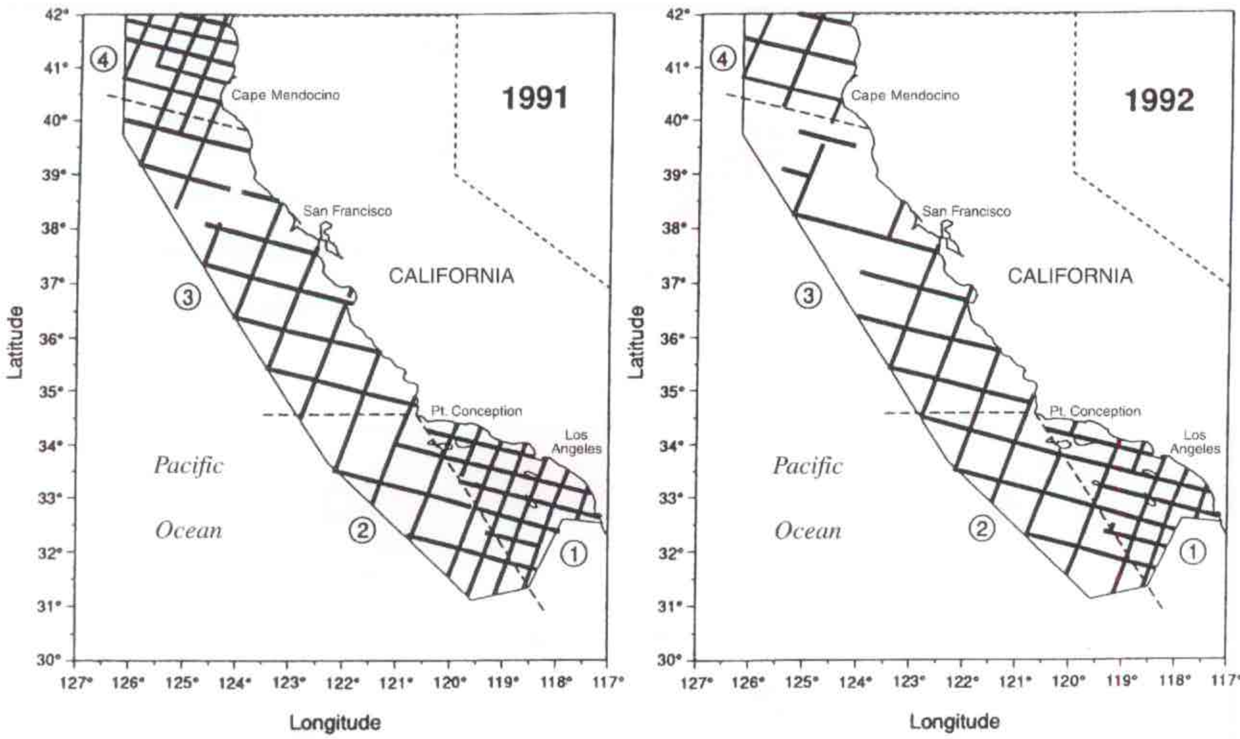


Figure 3.7-2
Transects surveyed (solid lines) by aircraft during winter and spring of (A) 1991 and (B) 1992 by NMFS/SWFSC.
There was one coverage of each transect. Also shown are geographic strata, separated by broken lines, used in their analyses. Stratum numbers are shown in circles. From Forney et al. (1995).

reported in Carretta and Forney (1993) and Forney et al. (1995 a,b). Their data were available in digital format for use here.

SWFSC Ship Surveys, 1991 and 1993

Ship-based surveys were conducted by NMFS/SWFSC along the coasts of Washington, Oregon and California during July to November 1991 and along the coasts of California and Northern Mexico during July to September 1993. Transects off California and Baja are shown in Figure 3.7-3 (studies 3 and 4 in Table 3.7-3). The survey area extended from the coast offshore to 300 NM (556 kilometers). Each transect was surveyed once during each year. The results of these surveys are reported in Hill and Barlow (1992), Barlow (1993), Forney and Barlow (1993), Mangels and Gerrodette (1994), Barlow (1995), and Barlow and Gerrodette (1996). Their data were available in digital format for use here.

SWFSC Aerial Surveys, 1993 to 1994

Aerial surveys were conducted by NMFS/SWFSC in a 5,493 square kilometer study area in the U.S. Navy Outer Sea Test Range (OSTR) west of San Nicolas Island during January 1993 through May 1994 (*A* in Figure 3.7-4; study 2 in Table 3.7-3). Each transect in study area ***A*** was surveyed once each month. Transects in study area ***B*** were surveyed during April and May 1994. In addition, many opportunistic sightings of marine mammals were made inshore of the main study area, primarily when transiting to and from the main study area. The results of these surveys are reported in Carretta et al. (1995). Their data were available in digital format for use here.

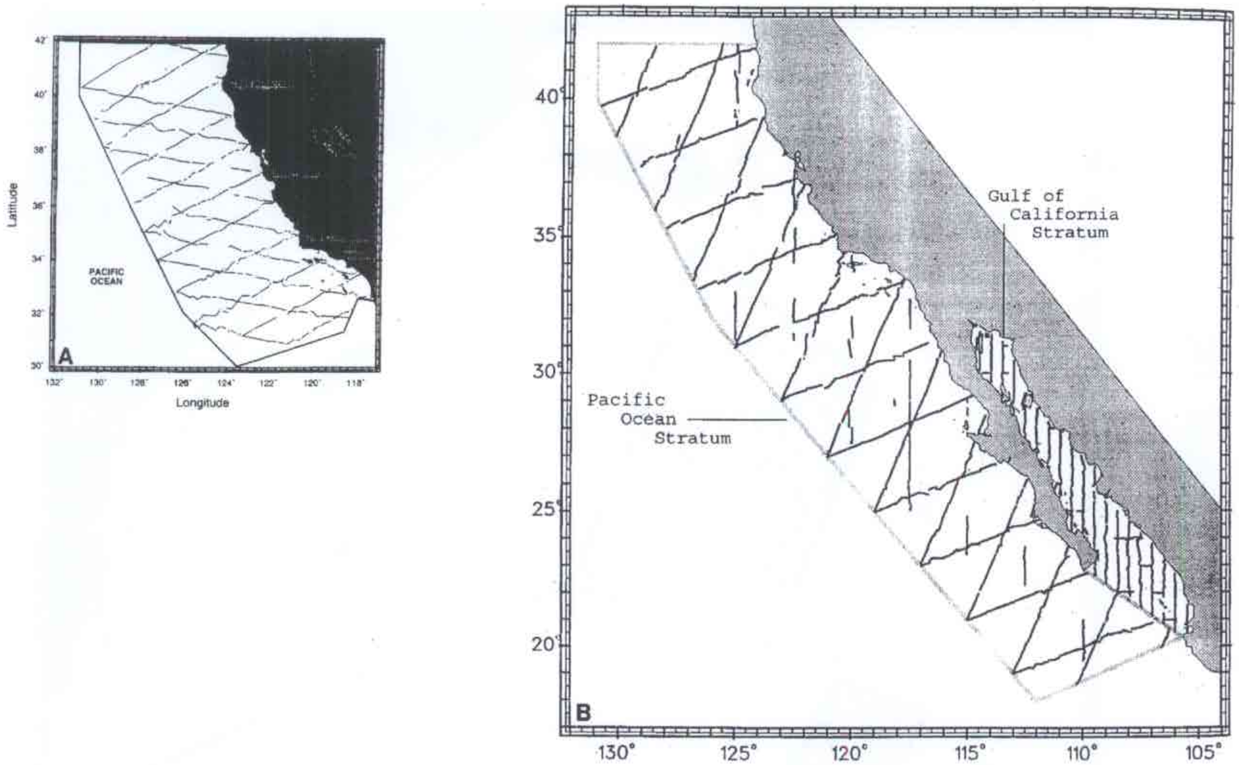


Figure 3.7-3
Transects surveyed by ship during summer and fall of *(A)* 1991 and *(B)* 1993 by NMFS/SWFSC. There was one coverage of each transect. Note that the scales in both panels are the same. The survey area in *(B)* includes Mexican waters that are not used to calculate population estimates for California waters. From Barlow (1995) and Mangels and Gerrodette (1994).

BLM/MMS Surveys, 1975 to 1978

Aerial surveys were conducted in offshore waters of the SCB from April 1975 to March 1978 (Figure 3.7-5; studies 5, 6, and 8 in Table 3.7-3). Each transect was surveyed once each month. High-altitude surveys (Figure 3.7-5*A*) were conducted at 1,000 feet (305 meters) above sea level (ASL) and low-altitude surveys were conducted at 200 feet ASL (Figure 3.7-5*B*). Ship-based surveys were also conducted; these provided opportunistic sightings of marine mammals (studies 7 and 8 in Table 3.7-3). The results of these surveys are reported in Dohl et al. (1981) and Bonnell et al. (1981).

Dohl et al. (1981) summarized their data into four "calendar" quarters: Spring (April to June), Summer (July to September), Autumn (October to December), and Winter (January to March). A different seasonal breakdown is used for the re-analyses of the BLM/MMS data presented in this report (see "Seasonal Presentation," below). Although species abundance may have changed since the BLM/MMS surveys were done in 1975 to 1978, relative seasonal abundance is expected to be similar for most species. Digital data from the 1975 to 1978 surveys were available for use here.

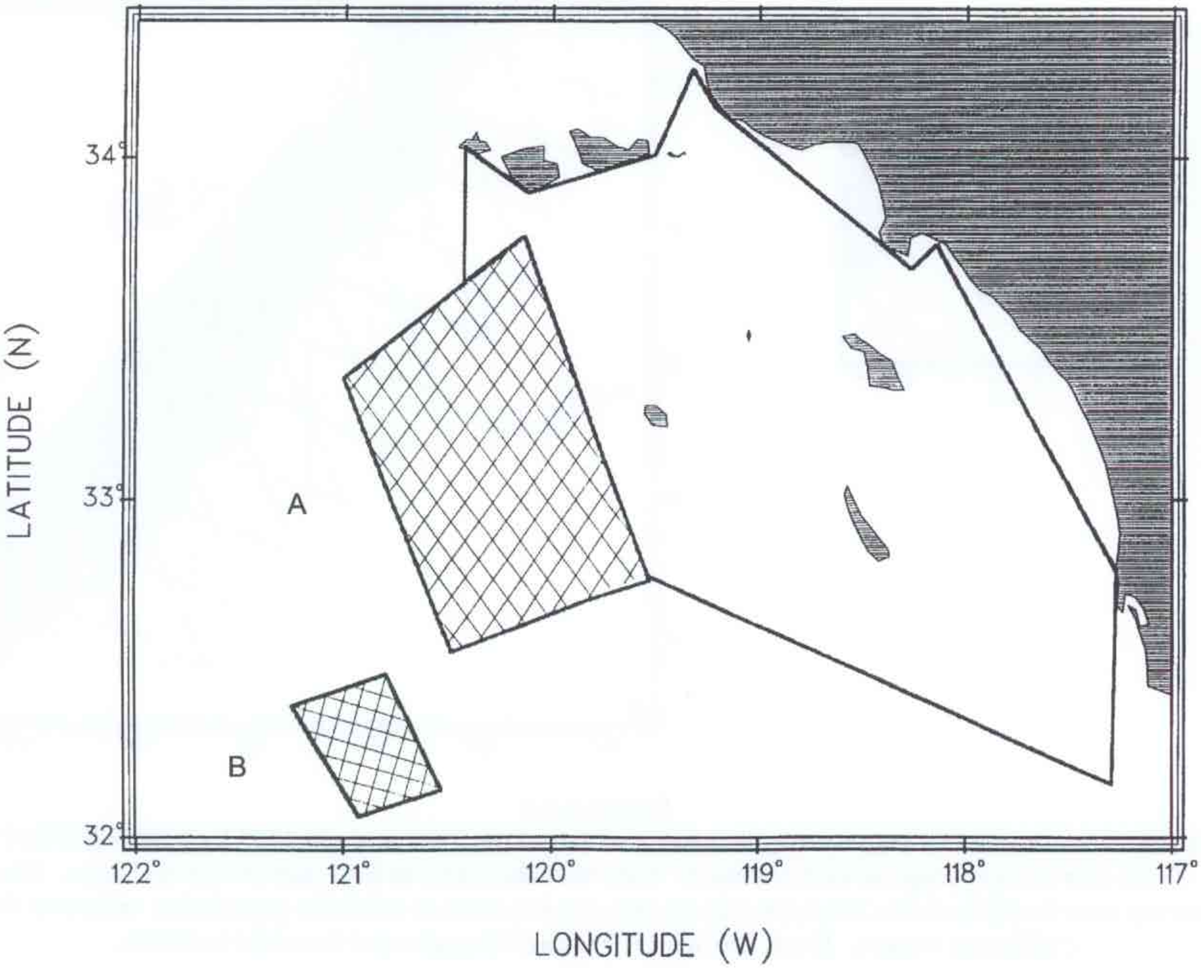


Figure 3.7-4
Transects surveyed (light lines) by aircraft monthly from January 1993 to May 1994 in the U.S. Navy Outer Sea Test Range by NMFS/SWFSC.
From Carretta et al. (1995).

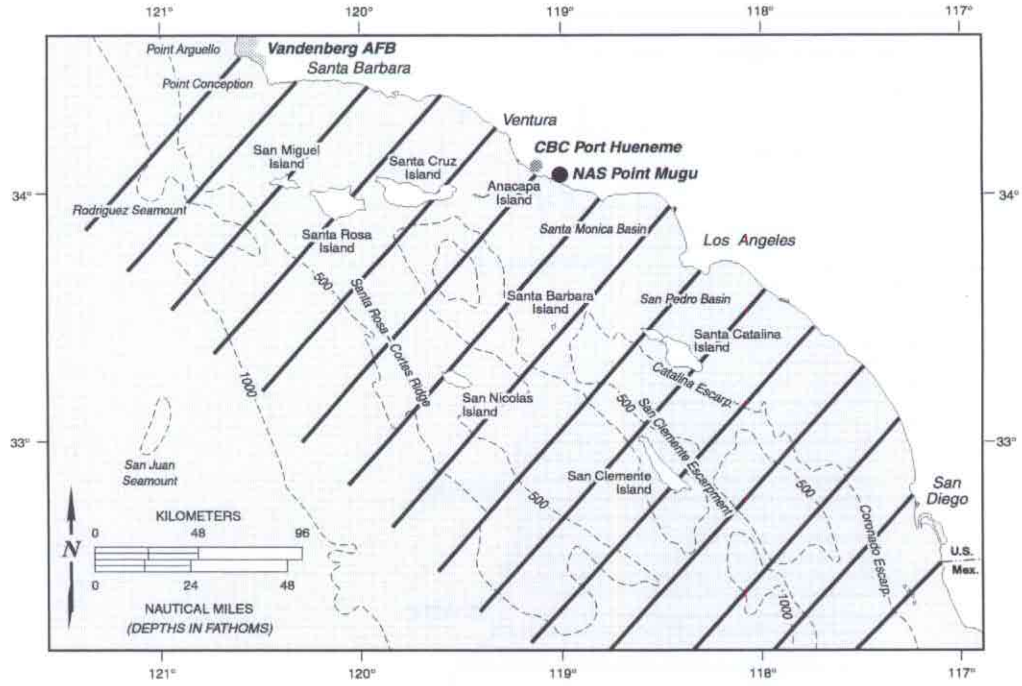
BLM/MMS Surveys, 1980 to 1983

Aerial surveys were conducted along the coast of central and northern California from March 1980 to February 1983 (Figure 3.7-6; studies 5, 6, and 8 in Table 3.7-3). Each transect was surveyed once each month. The results of these surveys are reported in Dohl et al. (1983) and Bonnell et al. (1983).

These surveys provide historical data on seasonal abundance of cetaceans and seals in the northern part of the Sea Range north of Point Conception (Figure 3.7-6). Digital data from the 1980 to 1983 surveys were available for use here. As in the case of the 1975-78 BLM/MMS surveys of the SCB, species abundance may have changed since these surveys were done, but relative abundance among seasons is expected to be similar for most species. Despite their age, the BLM/MMS data sets are an invaluable resource because of their duration (3 years in each area), year-round monthly coverage, and relatively close transect spacing.

A

High Altitude Transects



B

Low Altitude Transects

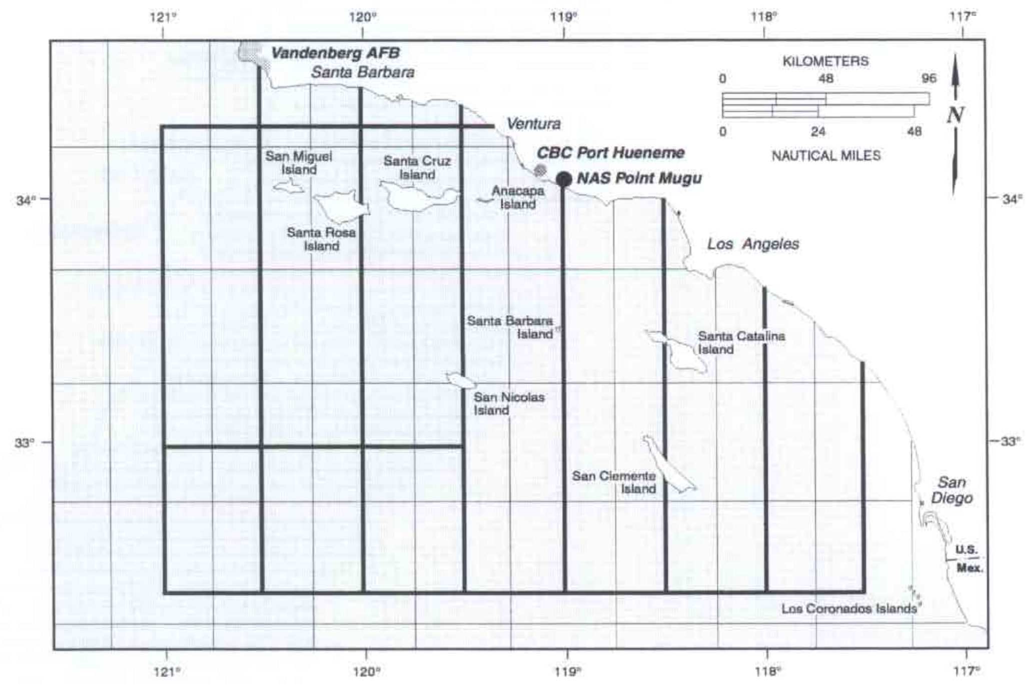


Figure 3.7-5

Transects surveyed by aircraft monthly from April 1975 to March 1978 by University of California Santa Cruz for BLM/MMS. *(A)* High altitude transects from Dohl et al. (1981) and *(B)* low altitude transects from Bonnell and Ford (1987).

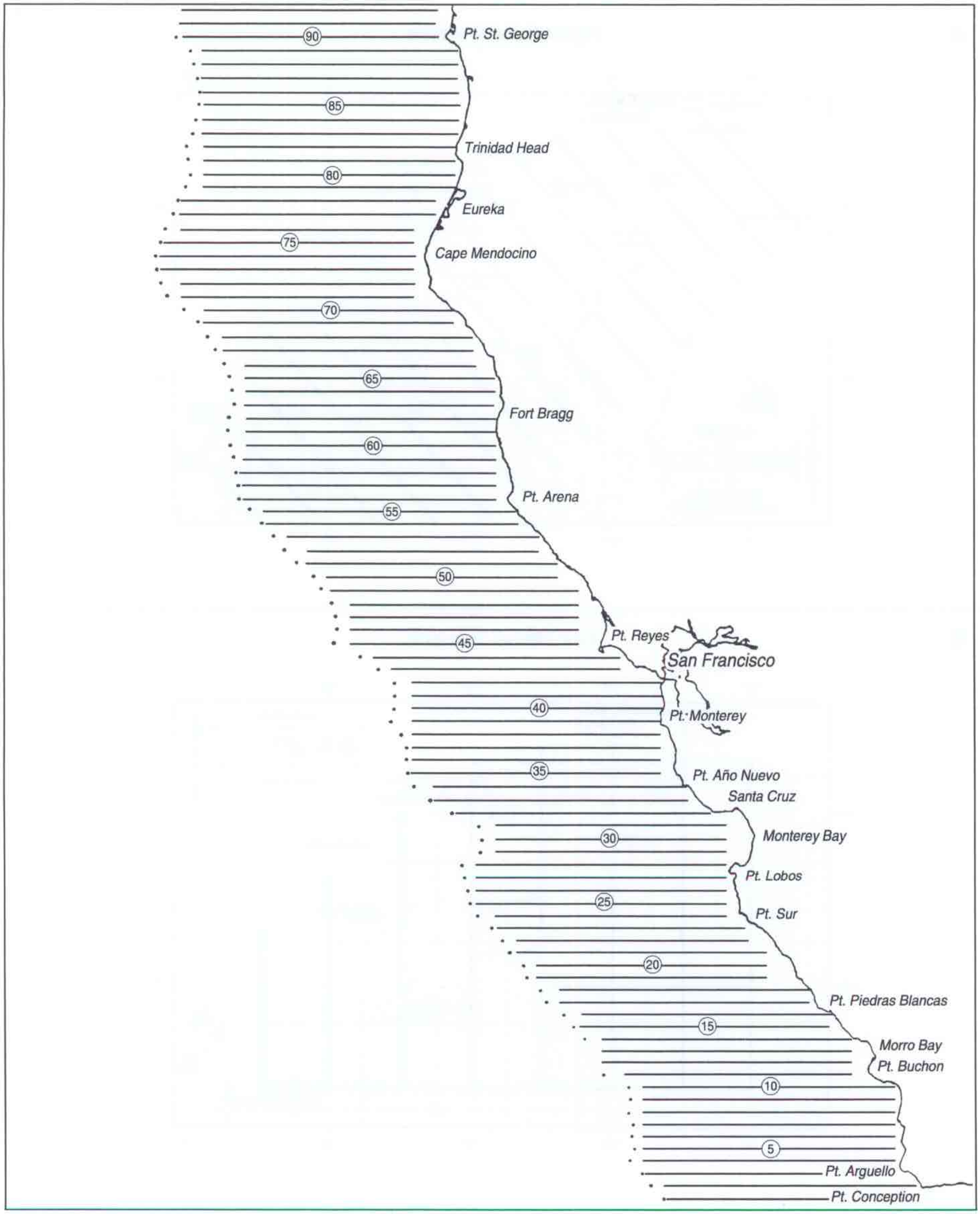


Figure 3.7-6
Transects surveyed by aircraft monthly from March 1980 to February 1983 by University of California Santa Cruz for BLM/MMS. From Dohl et al. (1983).

Platforms of Opportunity Program Database

Some opportunistic observations of marine mammals have been entered into the "Platforms of Opportunity Program" (POP) database, which is coordinated by Sally Mizroch at NMFS, National Marine Mammal Laboratory (NMML), Seattle, WA. These data do not have survey effort associated with them, and sighting effort was not systematic. These sightings are combined with other opportunistic sightings in summary maps prepared for this report (study 9 in Table 3.7-3).

MMS-OSPR Aerial Surveys

Data from ongoing aerial surveys by the University of Santa Cruz for MMS-OSPR have been obtained from Mike Bonnell. These surveys cover the Santa Barbara Channel and southern Santa Maria Basin, largely inshore of the boundaries of the Point Mugu Sea Range proper (study 10 in Table 3.7-3).

Other Data Sources

Two aerial surveys of the coast of central and southern California were conducted by the U.S. Fish and Wildlife Service for sea otters. The sightings from these surveys are included in the summary maps prepared for this report (study 11 in Table 3.7-3).

In addition to the databases that were obtained in digital form, several additional major studies or databases provide information on marine mammal distribution and abundance in and adjacent to the Sea Range. These studies are referenced where they provided information that supplemented the above studies. The most important of these studies are briefly described below.

Digital data on marine mammal strandings along the shores of the study area during 1981 to 1991 were provided by Joe Cordaro of NMFS, SW Region, Long Beach, CA. These records, mainly of dead animals on shore, are not included on the sighting maps or in the quoted numbers of sightings. However, for the less common species, records of stranded animals are mentioned in the text.

Leatherwood and Walker (1979) and Leatherwood et al. (1984) summarized Naval Ocean Systems Center (NOSC) aerial and ship survey effort in southern California for 1968 to 1976 (Figure 3.7-7). Their sighting and effort data were not available in digital form, but for some species maps of their sightings have been published. Their data are old and there have been major changes in both distribution and abundance for many species since their surveys.

3.7.1.5 Numbers in the Sea Range

Previous Estimates

Forney et al. (1995), Barlow and Gerrodette (1996), Barlow (1997), and Forney and Barlow (1998) have estimated population sizes for cetaceans off southern California, although not specifically for the waters included in the Point Mugu Sea Range. Their estimates are based on aerial survey data collected during winter (February to April) and ship-based surveys conducted during summer (August to October). Estimates of population abundance and densities from these surveys are summarized in Table 3.7-4.

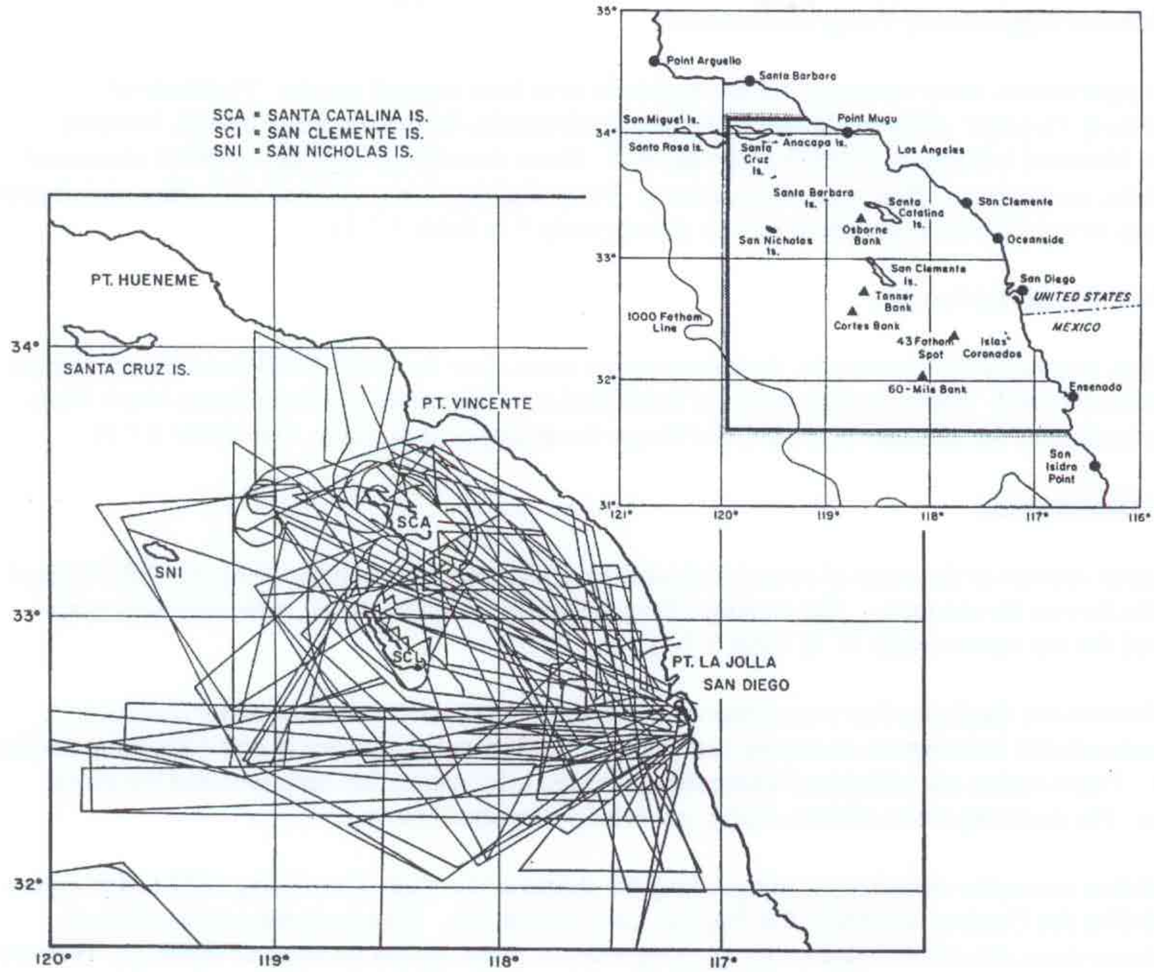


Figure 3.7-7
Area covered by Naval Ocean Systems Center aerial surveys, 1968-76.
The lower left figure shows the principal transects flown. From Leatherwood et al. (1984).

NMFS stratified the results of their aerial surveys conducted in winter (March and April 1991 and February to April 1992) to derive population estimates in various parts of the survey area. Our areas of interest include most of their Area 1, most of Area 2, and the southern part of Area 3 (Figure 3.7-2).

The NMFS estimates include correction factors to account for animals at the surface but missed by the observers and to account for the greater likelihood of spotting large groups vs. small groups. However, these estimates generally ***do not*** include correction factors to account for animals that were missed because they were below the surface as the aircraft or ship passed the animals (***availability bias***). This problem causes a greater underestimation of the number of animals present during aerial than during ship-based surveys, given the shorter potential observation time from a rapidly-moving aircraft. Correction factors for availability bias are under development by NMFS/SWFSC, but are available for only a few species (Barlow and Sexton 1996; Forney and Barlow 1998; Carretta et al. 1998).

Table 3.7-4. Population indices for cetaceans in waters offshore of California. Aerial survey data were reported by Forney et al. (1995); ship-based survey data were reported by Barlow and Gerrodette (1996). Unless noted, abundance indexes are not adjusted to account for diving behavior of animals, but do account for animals at the surface that were missed by observers.

	Aerial Surveys					Ship-based Surveys	
	Abundance Index		Density index (number/km^2)			Abundance Index	
Species	Total Area	CV	Area 1	Area 2	Area 3	Total Area	CV
Harbor porpoise	1,599	0.35	0.0000	0.0000	0.0079	52,743 [1]	0.68
Dall's porpoise	8,460	0.24	0.0342	0.0112	0.0395	47,700	0.40
Pacific white-sided dolphin	121,693	0.47	0.0573	0.2945	0.6218	11,200	0.36
Risso's dolphin	32,376	0.46	0.2029	0.0100	0.1860	10,700	0.41
Bottlenose dolphin-offshore	3,260	0.49	0.0684	0.0000	0.0008	1,850	0.50
Striped dolphin	n/c	n/c	n/c	n/c	n/c	24,900	0.31
Common dolphin - all	305,694	0.34	5.8769	0.4161	0.0588	380,980	n/c
Short-beaked	n/c	n/c	n/c	n/c	n/c	372,000	0.22
Long-beaked	n/c	n/c	n/c	n/c	n/c	8,980	0.64
Northern right whale dolphin	21,332	0.43	0.1378	0.1395	0.0341	8,980	0.50
Killer whale	65	0.69	0.0000	0.0005	0.0003	747	0.71
Short-finned pilot whale	n/c	n/c	n/c	n/c	n/c	1,000	0.37
Baird's beaked whale	n/c	n/c	n/c	n/c	n/c	380	0.52
Mesoplodon beaked whales	392	0.41	0.0000	0.0014	0.0009	2,106	0.79
Cuvier's beaked whale	n/c	n/c	n/c	n/c	n/c	9,160 [2]	0.52
Pygmy sperm whale	n/c	n/c	n/c	n/c	n/c	3,145	0.54
Sperm whale	892	0.99	0.0000	0.0134	0.0003	1,220	0.39
Northern right whale	16	1.11	0.0004	0.0000	0.0000	0	0.00
Gray whale	2,844	0.35	0.0145	0.0000	0.0170	n/c	n/c
Humpback	319	0.41	0.0004	0.0000	0.0009	577	0.31
Blue whale	30	0.99	0.0000	0.0005	0.0000	1,720	0.22
Fin whale	49	1.01	0.0011	0.0000	0.0000	933	0.27
Bryde's and Sei whales	n/c	n/c	n/c	n/c	n/c	124	1.09
Minke whale	73	0.62	0.0004	0.0000	0.0003	201	0.65

n/c – not calculated.
[1] From Barlow (1995).
[2] Corrected for the diving behavior of whales.

Normalization

In order to assess the impacts of proposed Navy activities on different species of marine mammals, it was necessary to estimate the average numbers of each species that might be present in various areas within the Sea Range at different times of year. Because of the different biases associated with different survey methods, it was not valid to use the data from the above studies as direct indicators of mammal densities or numbers at sea in various parts of the Sea Range. In addition to the above biases, the densities computed in the SWFSC reports and publications were computed for large areas that are subject to considerable variation in oceanographic conditions. Thus, the SWFSC mean densities were not directly applicable to the specific conditions in the Sea Range. Densities needed to be computed for smaller areas with geographic and oceanographic conditions that were similar to those in the Sea Range. With the guidance of NMFS/SWFSC personnel, a method was developed to account for the known biases,

inasmuch as possible, and to summarize the existing data according to the seasons and geographic areas required for this assessment.

Appendix A describes the procedures that were used to compute densities of marine mammals in the Sea Range and in each of the Sea Range areas. Densities of marine mammals at sea were derived primarily from recent NMFS/SWFSC ship and aerial survey data. In addition, the large amount of information from older surveys conducted for the MMS has been taken into account in estimating relative numbers present in different seasons. Densities were calculated separately for each species and (for the more common species) for each of four seasons. Densities were computed separately for the eight geographic areas or "strata" shown on Figure A-1B. Only effort and sightings from the Sea Range and relevant adjacent areas were used to compute densities. Densities were computed separately for areas within territorial waters along the coast of California, territorial waters adjacent to the Channel Islands, the continental shelf north of Point Conception, the continental shelf south of Point Conception, and offshore waters (Figure A-1B). Computed densities included correction factors to account for animals missed because they were below the surface (***availability bias***). Computed densities also included correction factors for animals at the surface but not sighted by the observers (***detectability bias***). These factors differ with type of marine mammal and type of survey (e.g., ship vs. aerial). Also, incompletely identified sightings, e.g. "unidentified pinniped" or "unidentified dolphin," have been taken into account by apportionment. The availability and detectability bias factors were from NMFS and SWFSC studies, where available, or were calculated based on surfacing and dive data from the literature. A detailed description of the methods used to estimate marine mammal densities and associated confidence intervals can be found in Appendix A.

The "corrected estimates" presented in this document are higher and presumably less biased than previous estimates based on the SWFSC data because the new estimates include factors to account for availability bias and unidentified animals. The individual estimates represent mean numbers expected during each of the seasons for which estimates could be computed. However, it is emphasized that these estimates are subject to much uncertainty and variability. A large number of assumptions and correction factors are involved. On any given day, considerably larger or smaller numbers of marine mammals could be present in each Sea Range area.

The stated coefficients of variation (CV) are indicators of the uncertainty in the estimated numbers present during the survey(s) on which the estimate is based. ***The uncertainty associated with movements of animals into or out of an area (due to factors such as availability of prey or changing oceanographic conditions) is much larger than is indicated by the CVs that are given.*** (Note: The CV is an index of uncertainty. It can range upward from zero, indicating no uncertainty, to high values. When CV exceeds 1.0, the estimate is very uncertain—actual values could range from zero to more than twice the "best" estimate.)

Seasonal Presentation

Previous studies conducted in southern California, including the BLM/MMS surveys of southern and central California, have generally summarized marine mammal data by calendar quarter, i.e. January to March, April to June, July to September, and October to December. Recent studies by SWFSC have recognized that changes in marine mammal distribution in southern California are often related to changes in oceanographic conditions that do not coincide with calendar seasons. Winter oceanographic conditions typically extend from February to April, spring conditions from May to July, summer conditions from August to October, and autumn conditions from November to January. When presenting and discussing seasonal distribution and abundance of marine mammals in the Sea Range, the

"oceanographic seasons" have been used because they better coincide with changes in marine mammal distribution (Forney 1997) and with the timing of recent SWFSC surveys. The original reports of pre-1990 studies were analyzed and presented by calendar quarter. Therefore, ***in some cases, the data have been interpreted differently here than in the original reports.***

3.7.2 Sea Range

This section describes the occurrence of marine mammals at sea within the Sea Range. Species occurring on land or close to shore are further described in subsequent sections concerning NAS Point Mugu, San Nicolas Island, and Other Channel Islands (Sections 3.7.3 to 3.7.5, respectively).

3.7.2.1 Odontocetes (Toothed Whales)

Harbor Porpoise, *Phocoena phocoena*

The harbor porpoise is common north of, and inshore of, the Sea Range, but is uncommon within the Sea Range itself. This species has not been listed under the ESA, but the Pacific Scientific Review Group has recommended that the central California stock of the harbor porpoise be included as a **strategic stock** due to possible declines in parts of its range (Forney 1995; Barlow et al. 1997).

In the eastern North Pacific, harbor porpoises occur in small groups in coastal waters within a mile or two of shore from Point Conception to Alaska (Bonnell and Dailey 1993). Harbor porpoises are rare in the SCB. Two separate stocks are recognized in California: a northern California stock and a central California stock (Barlow et al. 1997). The central and northern California stocks are estimated to include 4,120 (CV=0.22) and 9,250 (CV=0.23) animals, respectively (Barlow et al. 1997). These estimates are based on aerial surveys from 1988 to 1993, include correction factors to account for animals that were submerged at the time of the survey, and include the area between the coast and the 300-foot (91-meter) isobath. Russian River (approximately 38°28' north latitude) was considered the boundary between the central and northern stocks (Barlow and Forney 1994).

Although the harbor porpoise is the most common nearshore cetacean along central California, harbor porpoises rarely occur south of Point Conception (Dohl et al. 1983; Oliver and Jackson 1987). North of there, they are found primarily within 0.25 to 0.50 NM (460 to 920 meters) of the coast (Figure 3.7-8; Dohl et al. 1983). During the surveys whose results are summarized in Figure 3.7-8, only two sightings (involving one and three individuals) were made within the Sea Range. The Sea Range north of Point Conception does not include the coastal waters where harbor porpoises are more common. The two sightings within the present study area were both near the eastern border of Range Area M1. Based on the procedures described in Section 3.7.1.5, averages of 188, 85, 92, and 208 harbor porpoises may be present in winter (February to April), spring (May to July), summer (August to October), and autumn (November to January), respectively (Table 3.7-5). The autumn estimate of 208 animals represents 1.6 percent of the California population. However, these are overestimates because they are based on surveys that include coastal habitat, which harbor porpoises prefer. North of Point Conception, the Sea Range does not extend into coastal waters. The few harbor porpoises in the Sea Range are expected to occur in territorial waters (here considered to be waters within 12 NM [22.2 kilometers] of shore), given their preference for coastal waters.

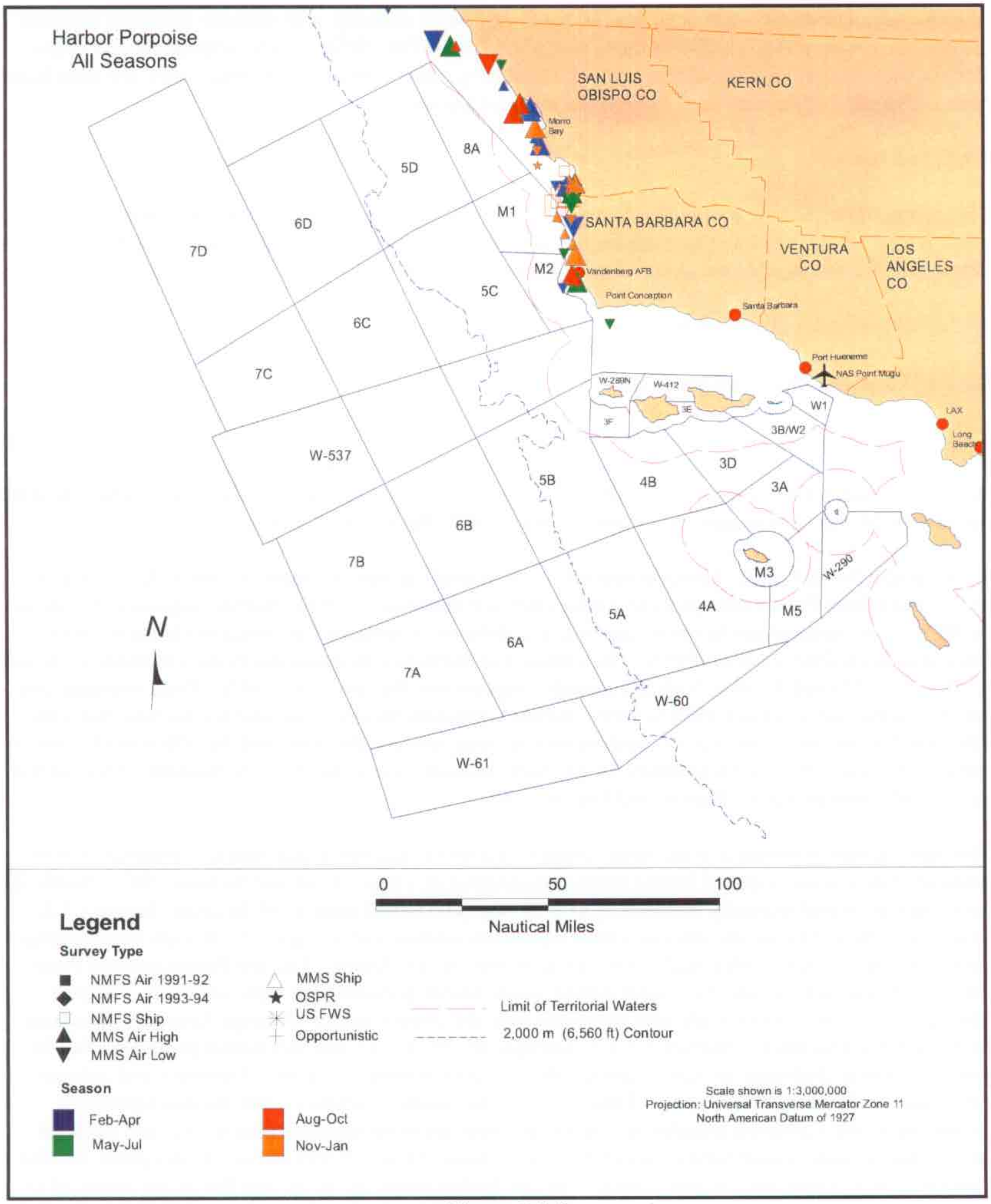


Figure 3.7-8

Sightings of harbor porpoises during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single vs. 2 or more animals, respectively.

Table 3.7-5. Estimated numbers of marine mammals of each species present in the Point Mugu Sea Range during each season. The estimated numbers incorporate estimates of availability bias. Estimation of CVs [1] is described in Appendix A.

Species	Numbers estimated to be present during months (CV) [1] Feb – Apr	May – Jun	Aug – Oct	Nov – Jan	Maximum Numbers Present
Harbor porpoise [2]	188 (>0.86)	85 (>0.99)	92 (>0.98)	208 (>0.84)	208
territorial waters	188 (>0.86)	85 (>0.99)	92 (>0.98)	208 (>0.84)	208
non-territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
Dall's porpoise	9,500 (0.54)	3,763 (>0.50)	2,514 (>0.60)	8,718 (0.50)	9,500
territorial waters	1,126 (0.72)	1,879 (0.88)	1,527 (0.87)	1,581 (0.80)	1,879
non-territorial waters	8,375 (0.60)	1,884 (0.46)	987 (0.76)	7,137 (0.59)	8,375
Pacific white-sided dolphin	22,765 (>0.50)	27,875 (0.50)	966 (>0.65)	24,739 (0.46)	27,875
territorial waters	103 (>1.46)	3,028 (1.07)	216 (>0.94)	9,467 (0.81)	9,467
non-territorial waters	22,662 (0.50)	24,847 (0.55)	750 (0.80)	15,273 (0.55)	24,847
Risso's dolphin	40,536 (0.45)	14,761 (>0.38)	11,645 (0.35)	41,865 (0.43)	41,865
territorial waters	8,272 (0.62)	75 (>0.94)	4,611 (0.62)	1,218 (0.85)	8,272
non-territorial waters	32,263 (0.54)	14,686 (0.38)	7,034 (0.42)	40,647 (0.44)	40,647
Coastal bottlenose dolphin	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
non-territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
Offshore bottlenose dolphin	534 (>0.94)	0 (>1.00)	2,942 (>0.47)	949 (>0.73)	2,942
territorial waters	0 (>1.00)	0 (>1.00)	1,776 (0.65)	409 (1.16)	1,776
non-territorial waters	534 (0.94)	0 (>1.00)	1,166 (0.63)	540 (0.94)	1,166
Common dolphin [3]	220,565 (0.34)	239,938 (>0.28)	154,461 (0.24)	233,639 (>0.40)	239,938
territorial waters	117,658 (0.50)	109,264 (>0.52)	81,134 (0.42)	88,969 (>0.54)	117,658
non-territorial waters	102,907 (0.47)	130,674 (>0.29)	73,326 (0.21)	144,670 (>0.55)	144,670
Northern right whale dolphin	87,128 (0.38)	77,774 (0.53)	4,058 (>0.63)	15,372 (0.56)	87,128
territorial waters	5,862 (0.79)	231 (1.37)	348 (>1.33)	1,477 (1.11)	5,862
non-territorial waters	81,266 (0.40)	77,543 (0.53)	3,710 (>0.68)	13,895 (0.61)	81,266
Short-finned pilot whale	Possible	Possible	Present	Possible	0
territorial waters	Possible	Possible	Present	Possible	0
non-territorial waters	Possible	Possible	Present	Possible	0
Cuvier's beaked whale	2,044 (>0.52)	2,044 (>0.52)	2,044 (>0.52)	2,044 (>0.52)	2,044
territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
non-territorial waters	2,044 (>0.52)	2,044 (>0.52)	2,044 (>0.52)	2,044 (>0.52)	2,044
Sperm whale	3,744 (>0.61)	0 (>1.00)	345 (>0.63)	5,013 (>0.78)	5,013
territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
non-territorial waters	3,744 (>0.61)	0 (>1.00)	345 (>0.63)	5,013 (>0.78)	5,013
Striped dolphin	0 (>1.00)	4,605 (>0.94)	7,887 (>0.57)	Present	7,887
territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
non-territorial waters	0 (>1.00)	4,605 (>0.94)	7,887 (>0.57)	Present	7,887
Spinner dolphin	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
territorial waters	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
non-territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
Spotted dolphin	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
territorial waters	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
non-territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
Rough-toothed dolphin	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
territorial waters	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
non-territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
Killer whale	361 (0.48)	361 (0.48)	361 (0.48)	361 (0.48)	361
territorial waters	43 (0.88)	43 (0.88)	43 (0.88)	43 (0.88)	43
non-territorial waters	318 (0.53)	318 (0.53)	318 (0.53)	318 (0.53)	318
False killer whale	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
territorial waters	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
non-territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0

Table 3.7-5. Estimated numbers of marine mammals of each species present in the Point Mugu Sea Range during each season (continued).

Species	Numbers estimated to be present during months (CV)[1] Feb – Apr	May – Jun	Aug – Oct	Nov – Jan	Maximum Numbers Present
Baird's beaked whale	<148 (>0.71)	148 (>0.71)	>148 (>0.71)	148 (>0.71)	148
territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
non-territorial waters	<148 (0.71)	148 (0.71)	>148 (0.71)	148 (0.71)	148
Other beaked whales	573 (>0.71)	573 (>0.71)	573 (>0.71)	573 (>0.71)	573
territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
non-territorial waters	573 (0.71)	573 (0.71)	573 (0.71)	573 (0.71)	573
Pygmy sperm whale	Possible	Possible	Present	Possible	0
territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
non-territorial waters	Possible	Possible	Present	Possible	0
Dwarf sperm whale	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
territorial waters	0 (>1.00)	0 (>1.00)	Possible	0 (>1.00)	0
non-territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
Northern right whale	Possible	Possible	0 (>1.00)	0 (>1.00)	0
territorial waters	Possible	Possible	0 (>1.00)	0 (>1.00)	0
non-territorial waters	Possible	Possible	0 (>1.00)	0 (>1.00)	0
Humpback whale	0 (>1.00)	125 (>0.59)	220 (>0.48)	13 (>0.94)	220
territorial waters	0 (>1.00)	8 (0.83)	101 (0.62)	0 (>1.00)	101
non-territorial waters	0 (>1.00)	117 (0.63)	119 (0.71)	13 (0.94)	119
Gray whale	2,345 (>0.41)	61 (>0.63)	0 (>1.00)	1,747 (>0.37)	2,345
territorial waters	1,704 (0.51)	61 (>0.63)	0 (>1.00)	1,505 (0.42)	1,704
non-territorial waters	641 (>0.65)	0 (>1.00)	0 (>1.00)	242 (>0.69)	641
Blue whale	266 (>0.94)	1,235 (>0.51)	1,612 (>0.29)	0 (>1.00)	1,612
territorial waters	0 (>1.00)	35 (>1.00)	135 (>0.72)	0 (>1.00)	135
non-territorial waters	266 (>0.94)	1,200 (>0.52)	1,478 (0.31)	0 (>1.00)	1,478
Fin whale	262 (>0.72)	182 (>0.68)	1,477 (>0.38)	492 (>0.58)	1,477
territorial waters	0 (>1.00)	11 (>0.94)	0 (>1.00)	253 (>0.94)	253
non-territorial waters	262 (>0.72)	171 (>0.72)	1,477 (>0.38)	239 (>0.65)	1,477
Sei whale	0 (>1.00)	0 (>1.00)	9 (>0.94)	0 (>1.00)	9
territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
non-territorial waters	0 (>1.00)	0 (>1.00)	9 (>0.94)	0 (>1.00)	9
Bryde's whale	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
non-territorial waters	0 (>1.00)	0 (>1.00)	0 (>1.00)	0 (>1.00)	0
Minke whale	179 (0.68)	179 (0.68)	179 (0.68)	179 (0.68)	179
territorial waters	21 (0.89)	21 (0.89)	21 (0.89)	21 (0.89)	21
non-territorial waters	158 (0.62)	158 (0.62)	158 (0.62)	158 (0.62)	158
Harbor seal	914 (>0.65)	2,860 (>0.49)	927 (>0.69)	2,065 (>0.64)	2,860
territorial waters	914 (>0.65)	2,026 (>0.57)	306 (>0.82)	2,065 (>0.64)	2,065
non-territorial waters	0 (>1.00)	834 (>0.94)	621 (>0.94)	0 (>1.00)	834
Northern elephant seal	26,623 (>0.39)	6,495 (>0.50)	7,409 (>0.33)	11,356 (>0.48)	26,623
territorial waters	9,221 (>0.55)	3,976 (>0.71)	1,617 (>0.54)	1,737 (>0.58)	9,221
non-territorial waters	17,401 (0.52)	2,519 (>0.65)	5,792 (0.39)	9,619 (0.56)	17,401
California sea lion	45,227 (0.27)	163,512 (0.18)	72,276 (0.15)	133,414 (0.20)	163,512
territorial waters	22,692 (0.32)	87,635 (0.22)	45,579 (0.19)	47,964 (0.21)	87,635
non-territorial waters	22,535 (0.42)	75,876 (0.29)	26,696 (0.24)	85,449 (0.28)	85,449
Northern fur seal	44,641 (>0.23)	3,828 (>0.46)	2,553 (>0.31)	22,914 (>0.36)	44,641
territorial waters	807 (>0.65)	36 (>0.83)	195 (>0.62)	441 (>0.87)	807
non-territorial waters	43,834 (0.23)	3,792 (0.47)	2,358 (>0.33)	22,474 (0.36)	43,834

[1] CV = coefficient of variation of the estimate. CVs that are given underestimate the true variation because they do not take account of variation associated with the diving behavior of marine mammals (see Appendix A).

[2] Includes separate estimates for central and northern California.

[3] Includes both short-beaked and long-beaked common dolphins.

Numbers of harbor porpoises in central California have declined from 1986 to 1993 (Forney 1995), perhaps because they shifted their distribution in response to environmental changes, e.g. sea surface warming. Leatherwood et al. (1987) speculated that, if the population grows and if a period of cooling occurs in the SCB, harbor porpoises may venture southward. At present though, central California harbor porpoise populations are reduced, with an annual 9.3 percent (CV=0.56) decline during the 1986 to 1993 period (Forney 1995). Whether this decline is due to emigration or to reduced survival is unknown.

Harbor porpoises dive to depths less than 660 feet (200 meters) and feed mainly on bottom-dwelling fish and invertebrates. Their diet includes northern anchovy, spotted cusk eel, rockfish, cod, herring, flounder, hake, squid, clams, and assorted crustaceans (Dohl et al. 1983; Sekiguchi 1995).

In summary, harbor porpoises do not have a special status in California and fewer than 200 individuals are expected to be found within the Sea Range. However, the species is common inshore of the northern part of the Sea Range. They are more abundant in the Sea Range during autumn and winter than during spring and summer. They dive to depths less than 660 feet (200 meters) and feed mainly on bottom-dwelling fish and invertebrates.

Dall's Porpoise, *Phocoenoides dalli*

Dall's porpoise is common in the Sea Range. It is not listed under the ESA and Dall's porpoises found in the Sea Range are not part of a strategic stock. No specific data are available regarding trends in population size in California or adjacent waters.

Dall's porpoises are endemic to temperate waters of the North Pacific and are commonly seen throughout their range in shelf, slope, and offshore waters. Their range in the eastern North Pacific extends from Alaska south to Baja California (Morejohn 1979). The Dall's porpoise is probably the most abundant small cetacean in the North Pacific Ocean.

This species is found throughout the Sea Range, but its abundance changes seasonally, probably in relation to water temperature (Figures 3.7-9 to 3.7-12). It is considered to be a cold-water species and is rarely seen in areas where water temperatures exceed 17°C (Leatherwood et al. 1982). Its distribution shifts southward and inshore in autumn, especially near the northern Channel Islands, and northward and offshore in late spring (Dohl et al. 1981; Leatherwood et al. 1987; Barlow et al. 1997; Figures 3.7-9 to 3.7-12). Within the SCB, Dohl et al. (1981) reported a population increase in autumn and winter, with peak densities in November and December; numbers in the SCB tended to decline during spring and summer (Figure 3.7-13). Few Dall's porpoises were sighted south of Point Conception during summer ship surveys in 1991 and 1993 (Hill and Barlow 1992; Mangels and Gerrodette 1994). In the US Navy-OSTR during 1993 to 1994, Carretta et al. (1995) report the highest density (0.54 per 1,000 NM or 0.29 per 1,000 kilometers) in winter to early spring (March to May; corresponds to their spring season in Table 3.7-6) and no sightings in June to August (Table 3.7-6).

Within the Sea Range, Dall's porpoises are abundant throughout the continental slope and offshore waters during winter (Figure 3.7-9). They are also seen during winter at a variety of nearshore locations, including the south coast of the northern Channel Islands and near Santa Barbara Island (Dohl et al. 1981; Leatherwood et al. 1987). Although their distribution shifts northward during spring, summer, and autumn, there are frequent sightings in Santa Barbara Channel in all seasons; this area is outside of, but adjacent, to the Sea Range (Figures 3.7-10 to 3.7-12).

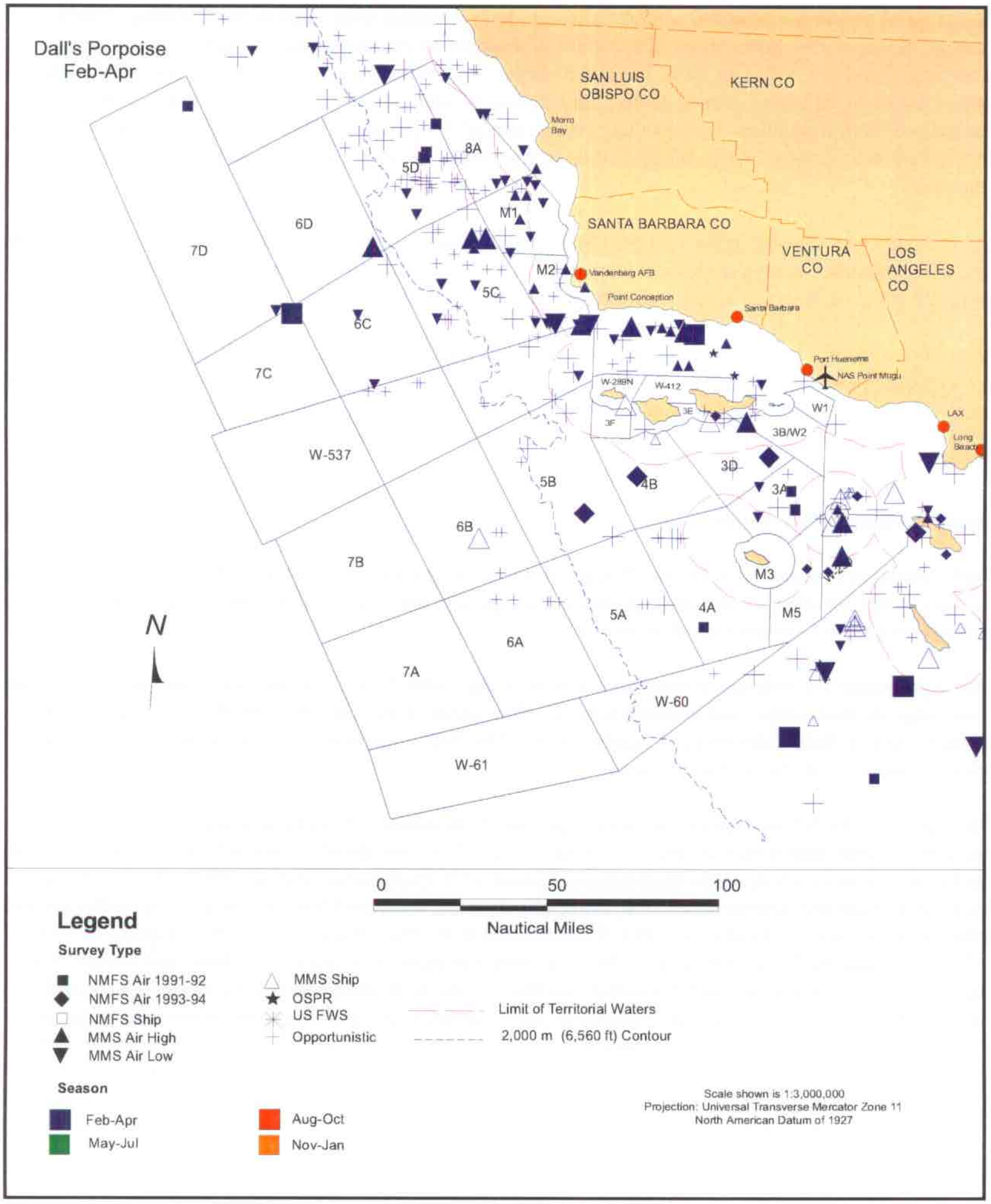


Figure 3.7-9

Sightings of Dall's porpoises during the February-April 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-4 vs. 5 or more animals, respectively.

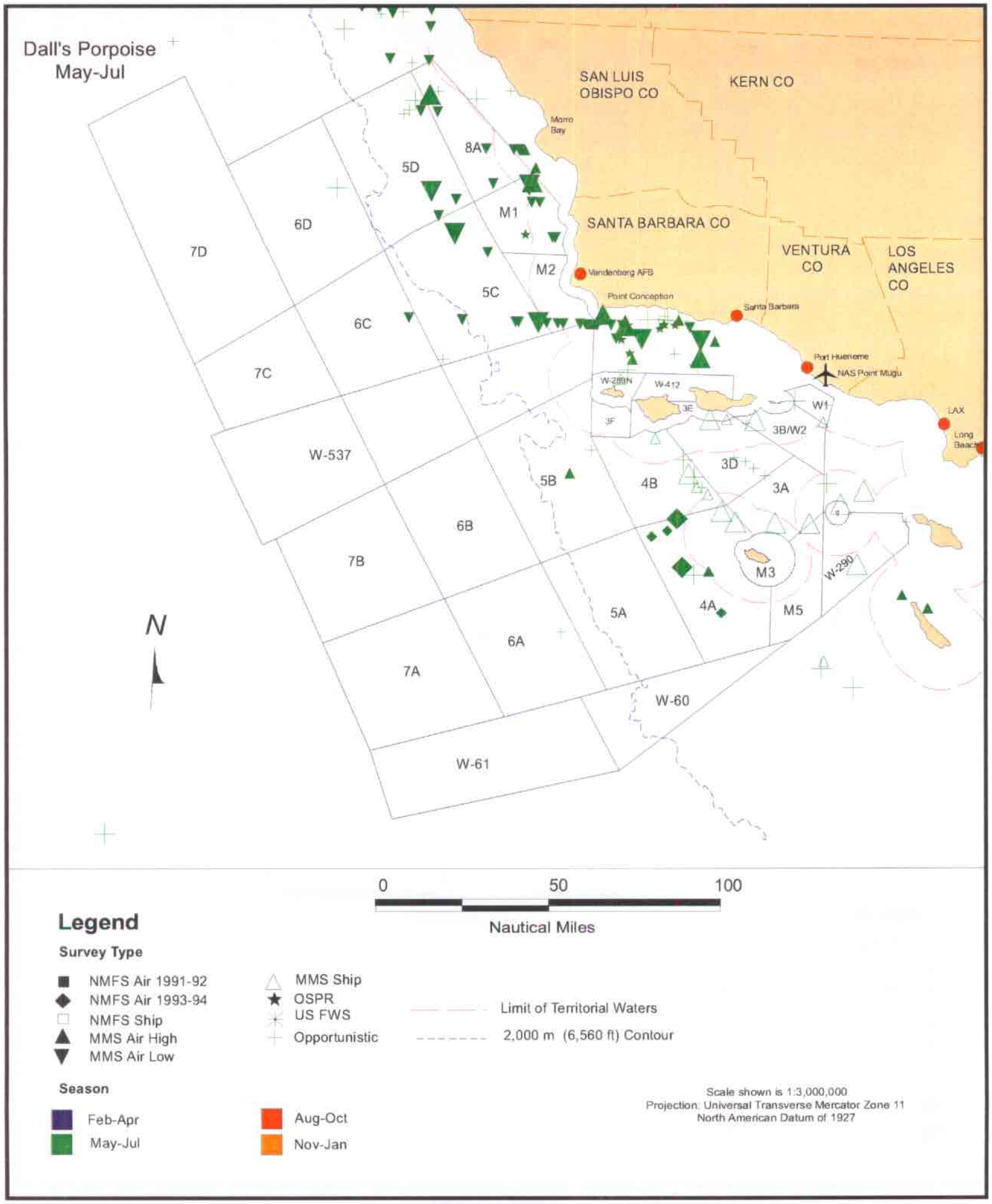


Figure 3.7-10
Sightings of Dall's porpoises during the May-July 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-4 vs. 5 or more animals, respectively.

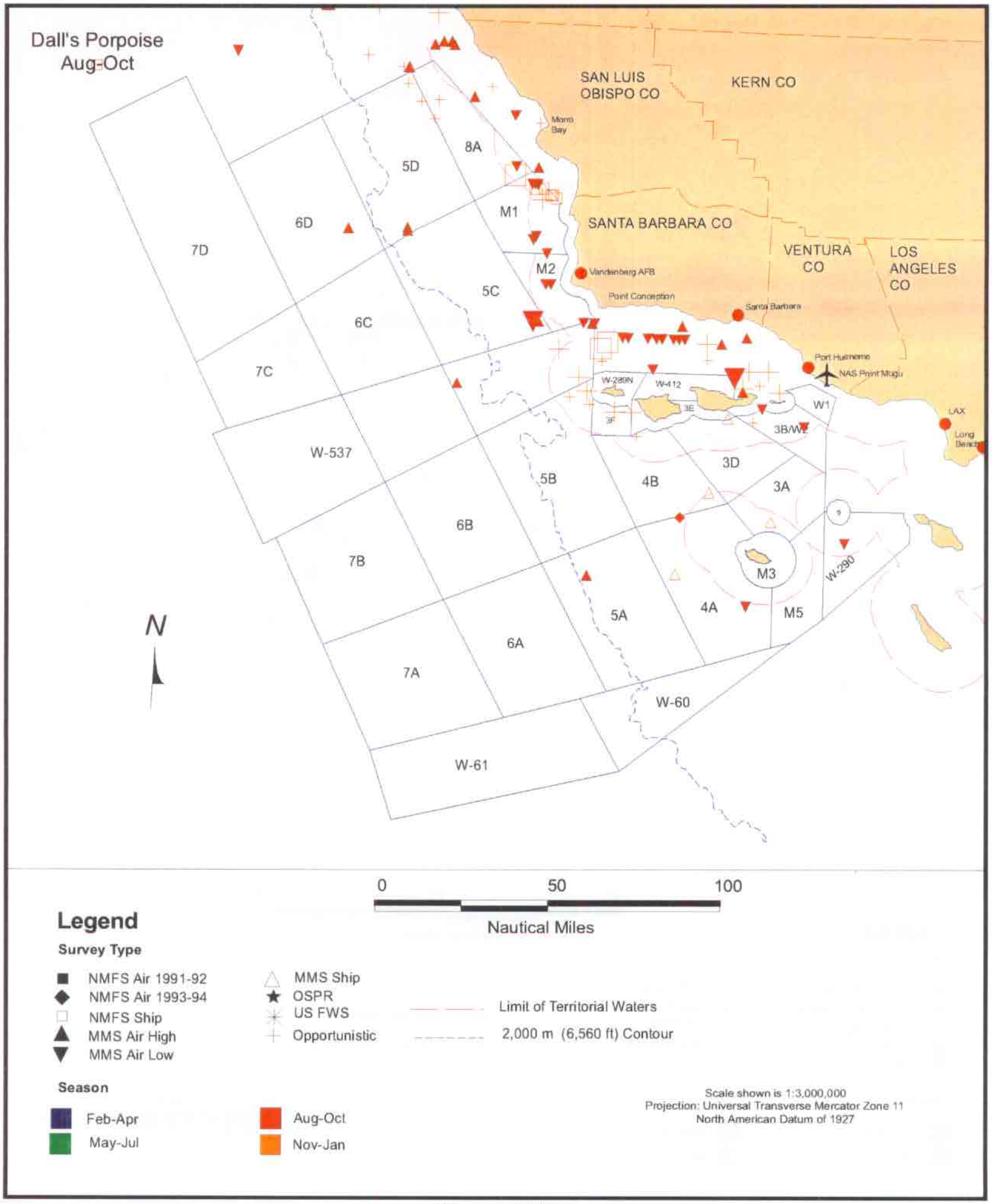


Figure 3.7-11

Sightings of Dall's porpoises during the August-October 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-4 vs. 5 or more animals, respectively.

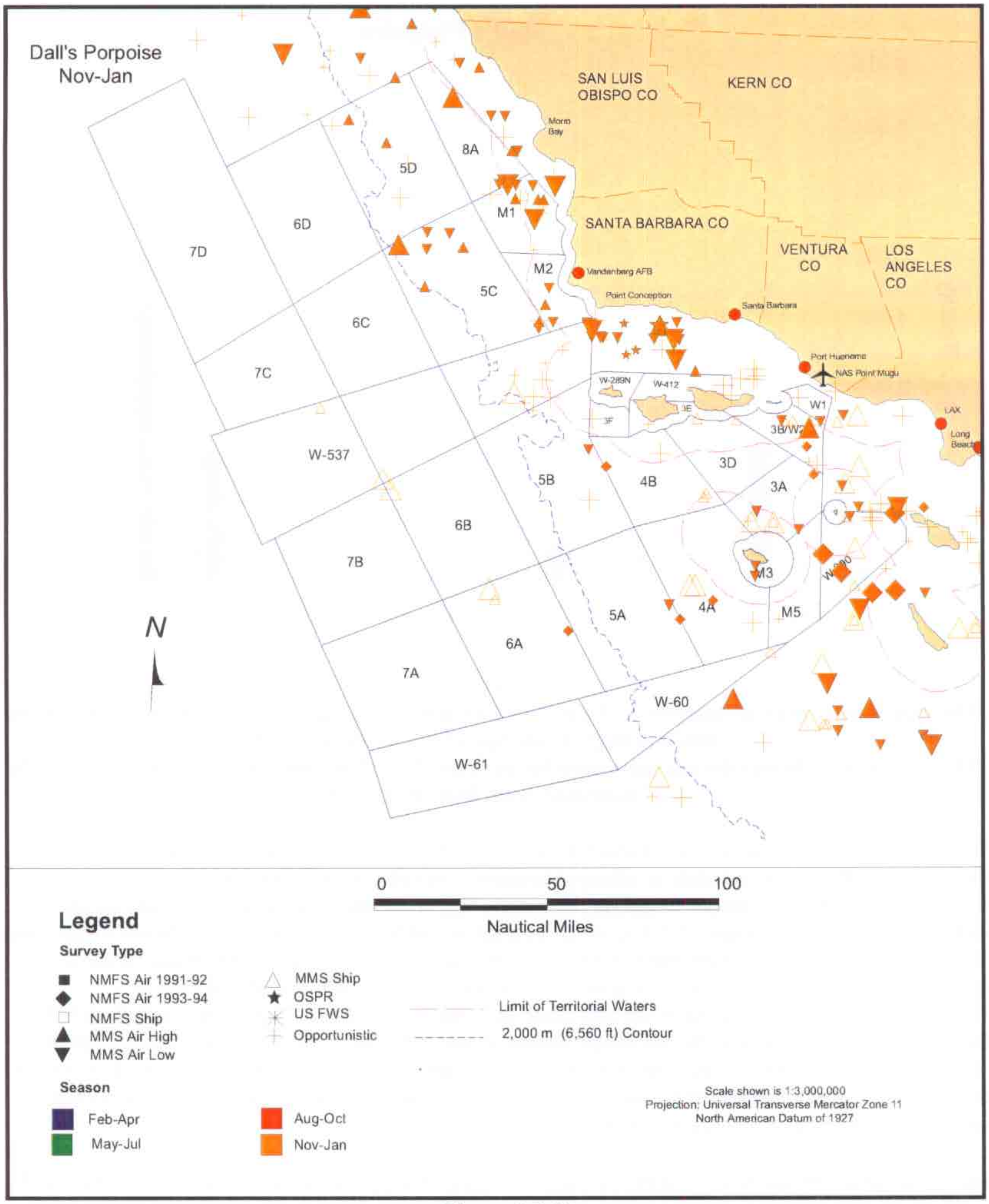


Figure 3.7-12

Sightings of Dall's porpoises during the November-January 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-4 vs. 5 or more animals, respectively.

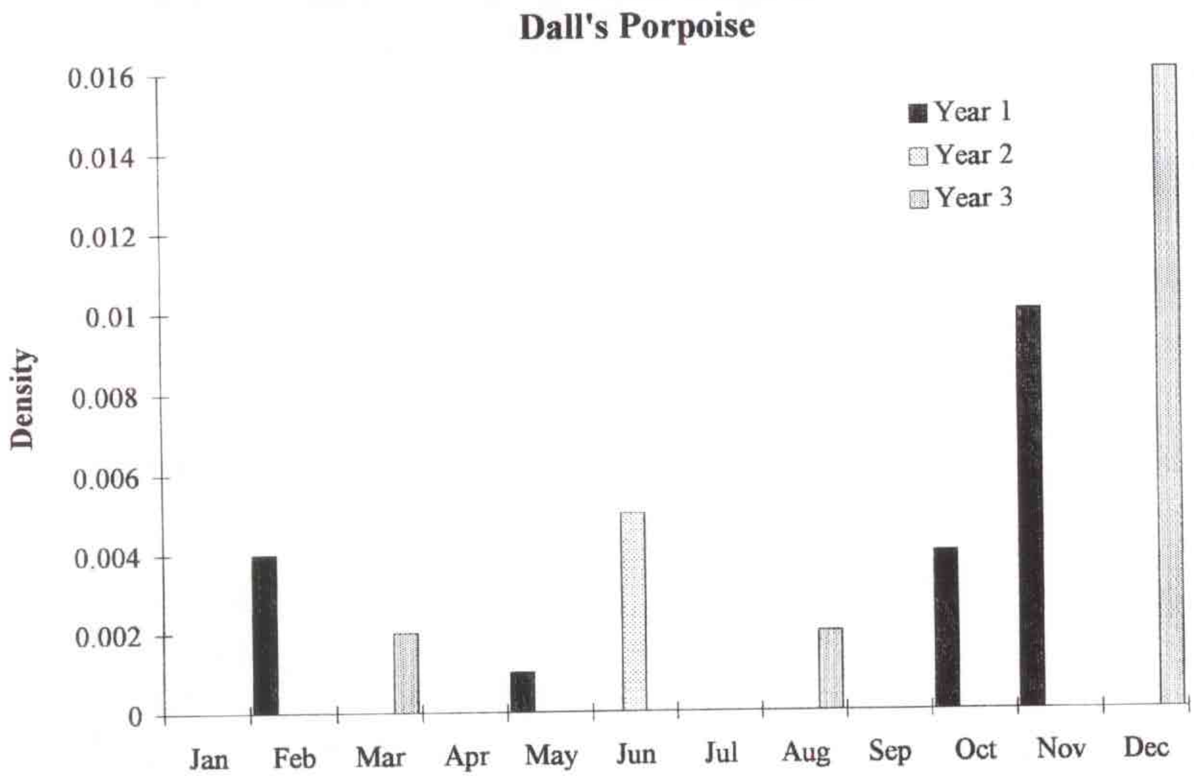


Figure 3.7-13
Monthly density indices (number/NM^2) of Dall's porpoises during aerial surveys in the Southern California Bight from April 1975 to March 1978.
There were no sightings during most monthly periods. Year 1 is from April 1975 to March 1976, etc. Replotted from Dohl et al. (1981).

The best estimate of stock size for California waters is 47,661 (CV=0.40)(Barlow and Gerrodette 1996; Barlow et al. 1997). This estimate is unbiased because it includes a correction factor to account for the diving behavior of Dall's porpoises during the survey. This estimate is based on ship-based surveys within the area shown in Figure 3.7-3A, which extends to 300 NM (556 kilometers) offshore of the coast of California. A much lower estimate (8,460) was obtained by Forney et al. (1995) based on aerial surveys of the smaller area shown in Figure 3.7-2, which extends to 100 to 150 NM (185 to 278 kilometers) offshore. Based on the procedure described in Section 3.7.1.5, approximately 9,500 Dall's porpoises occur within the Sea Range during winter and only 1,276 occur there during summer (Table 3.7-5). Thus about 20 percent (winter) to 2.7 percent (summer) of the California stock occurs in the Sea Range, depending on the season. As many as 8,375 Dall's porpoises occur in non-territorial waters and as many as 1,879 occur in territorial waters.

Some segregation by age and sex seems to occur. In some areas, juveniles are found close to shore and larger adults well offshore. Among adults, pregnant and lactating females are distributed farther north than males and non-parous females (Leatherwood et al. 1987).

Although feeding aggregations of up to 200 individuals have been sighted (Leatherwood et al. 1987), recent sightings in and near the Sea Range have been of groups averaging 3.1 to 3.3 individuals (Barlow 1995; Forney et al. 1995). The average size of 401 groups seen within the Sea Range during the studies

Table 3.7-6. Seasonal[1] group encounter rates and mean group sizes for species sighted during on-effort surveys within the SWFSC-OSTR survey area. Only species detected five times or more are included. From Tables 4 to 6 of Carretta et al. 1995.

Species	Total Number Of Sightings	Sightings/1000 NM				
		Winter[1]	Spring	Summer	Autumn	Overall
Dolphins and porpoises						
Common dolphin	54	0.92	1.51	6.43	1.95	2.11
Northern right whale dolphin	26	1.62	1.41	-	-	1.03
Risso's dolphin	24	1.62	0.92	0.54	-	0.92
Pacific white-sided dolphin	17	0.70	0.49	1.62	0.22	0.65
Dall's porpoise	10	0.32	0.54	-	0.43	0.38
Whales						
Sperm whale	7	0.81[2]	-	-	0.22	0.27
Cuvier's beaked whale	6	0.32	0.11	-	0.43	0.22
All beaked whales[3]	11	0.32	0.32	-	1.08	0.43
Fin whale	11	0.43	0.11	0.54	0.86	0.43
Blue whale	8	-	-	2.16	-	0.32
Pinnipeds						
California sea lion	237	9.03	10.59	13.73	3.95	9.84
Northern elephant seal	13	0.54	0.70	0.27	0.22	0.54
Species	**Total Number Of Sightings**	**Mean Group Size**				
		Winter	**Spring**	**Summer**	**Autumn**	**Overall**
Dolphins and porpoises						
Common dolphin	54	594.1	113.0	171.4	1,037.8	363.8
Northern right whale dolphin	26	75.1	1,536.8	-	-	749.7
Risso's dolphin	24	150.8	234.1	234.1	-	185.4
Pacific white-sided dolphin	17	143.2	231.4	64.9	54.1	130.8
Dall's porpoise	10	23.2	25.4	-	10.8	21.6
Whales						
Sperm whale	7	20.5[2]	-[2]	-	8.1	19.5
Cuvier's beaked whale	6	10.8	5.4	-	8.1	9.2
Fin whale	11	5.9	5.4	13.5	10.3	8.6
Blue whale	8	-	-	8.1	-	8.1
Pinnipeds						
California sea lion	237	8.1	7.6	7.0	8.6	7.6
Northern elephant seal	13	5.4	5.4	5.4	5.4	5.4

[1] In their study winter=December-February; spring=March-May; summer=June-August; autumn=September-November.
[2] Corrected from Tables 5 and 6 of Carretta et al. (1995).
[3] Includes Cuvier's, Baird's, and unidentified beaked whales.

summarized here (see Table 3.7-3) was 4.2 animals, and the largest group contained 40 individuals. The preferred prey species of Dall's porpoises in southern California include a wide range of fish and cephalopods, including anchovy, herring, juvenile rockfish, sauries, hake, jack mackerel, and squid (Morejohn 1979; Dohl et al. 1981; Leatherwood et al. 1987). Dall's porpoises apparently feed at night, depending to some degree on the deep scattering layer, and are inactive during most of the day (Leatherwood et al. 1987).

Dall's porpoises are commonly attracted to moving vessels where they "bow ride," sometimes for long periods of time.

In summary, the Dall's porpoise does not have a special status. It is the most abundant cetacean in the North Pacific Ocean, although not on the Sea Range (see Common Dolphin, below). During the winter, it is common throughout the Point Mugu Sea Range and approximately 9,500 individuals (20 percent of the California population) are present in this area at that time. There are seasonal changes in distribution and abundance; these changes are probably related to changes in water temperature. During the spring and autumn, lower numbers are present in the Sea Range. Relatively few Dall's porpoises are present in the southern part of the Sea Range during summer, but low to moderate numbers remain in the northern part. Juveniles are more likely to be found close to shore and large adults farther offshore. Females with calves remain mainly outside of the Sea Range. Dall's porpoises feed primarily at night on fish and cephalopods.

Pacific White-sided Dolphin, *Lagenorhynchus obliquidens*

The Pacific white-sided dolphin is common in the Sea Range. It is not listed under the ESA, and those individuals found in the Sea Range are not part of a strategic stock. There are no available data regarding trends in population size in California or adjacent waters.

The Pacific white-sided dolphin occurs in temperate waters of the North Pacific Ocean and it may be the most abundant delphinid in that area. It occurs in continental shelf, continental slope, and offshore waters east of 180° west longitude from Baja California to southern Alaska (Leatherwood et al. 1984, 1987). In the eastern North Pacific there are two putative stocks of white-sided dolphins: a larger, southern form and a smaller northern form (Walker et al. 1986 *in* Heyning et al. 1994). In the southern part of their range (20° to 34° north latitude) they have been observed mainly shoreward of the outer margin of the California Current. A few sightings have been made in waters as shallow as 60 feet (18 meters) in winter (near San Diego, Santa Monica, and Santa Barbara), but the Pacific white-sided dolphin seems to prefer deeper waters (Leatherwood et al. 1987).

There is conflicting evidence concerning seasonal shifts in distribution and numbers of Pacific white-sided dolphins in the Point Mugu Sea Range. The different interpretations by various authors may reflect whether they used sightings or "sightings per unit effort" to map distribution, and whether the limited survey effort in some areas and seasons was taken into account. Movement patterns may also change from year to year. This species may tend to move southward in winter and northward (or perhaps offshore) in the summer (Leatherwood et al. 1984), but one study found higher numbers in nearshore areas of the SCB in summer (Dohl et al. 1981; Bonnell and Dailey 1993). Analyses of many years of data suggest that peak numbers probably occur in the Point Mugu Sea Range in winter (Leatherwood et al. 1984; Figure 3.7-14).

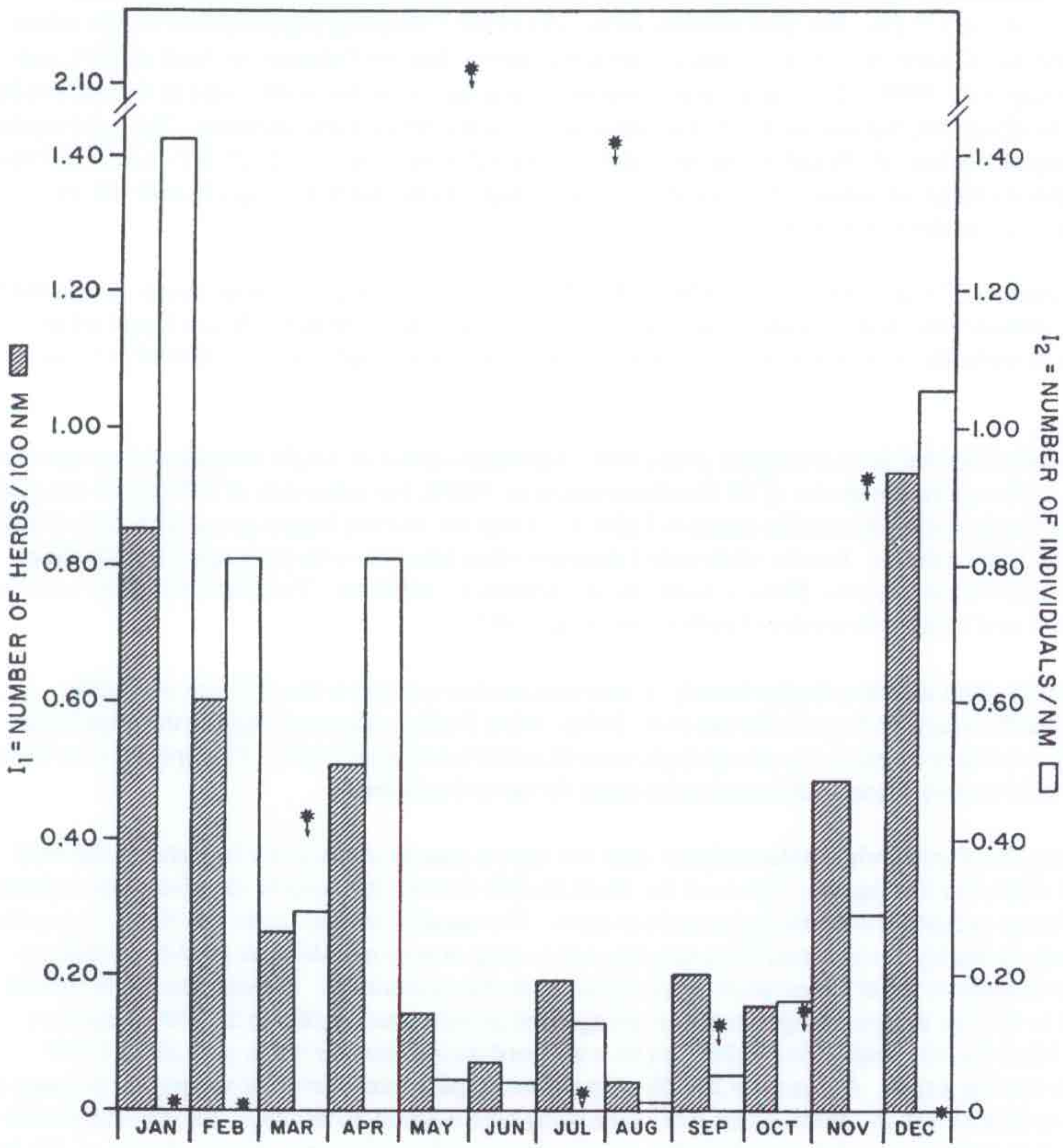


Figure 3.7-14
Indices of abundance of Pacific white-sided dolphins off southern California, 1968-76, based on NOSC aerial surveys.
The * symbols indicate I_2 indices values calculated from Table III-93 in Dohl et al. (1980) for the same area, May 1975 - March 1976. From Leatherwood et al. (1984).

Pacific white-sided dolphins appear to be common throughout the Point Mugu Sea Range, with the possible exception of the most westerly (offshore) areas where there has been little survey effort (Figures 3.7-15 to 3.7-18). The best estimate of the size of the California population of Pacific white-sided dolphins, 121,693 (CV=0.47), comes from aerial survey data for February to April in 1991 and 1992 (Forney et al. 1995). This estimate is corrected to account for animals that were at the surface but not seen by observers, but not for the diving behavior of Pacific white-sided dolphins. Thus, the estimate may be negatively biased. Based on the procedure described in Section 3.7.1.5, 22,765 to 27,875 Pacific white-sided dolphins are estimated to occur in the Sea Range during autumn to spring and 966 are estimated to occur there in summer.

An estimated 15,273 to 24,847 Pacific white-sided dolphins occur in non-territorial waters within the Sea Range at various times from autumn to spring. During summer approximately 750 are found there. Numbers in territorial waters are more variable; seasonal estimates range from 103 to 9,467 (Table 3.7-5).

Pacific white-sided dolphins are highly gregarious. Sightings consist of single animals and groups of two to 6,000, with a mean group size of 88 (Leatherwood et al. 1984); the mean size of 348 groups recorded in the Sea Range during the studies listed in Table 3.7-3 was 80, and the largest group sighted in the Sea Range was 2,500 animals. Pacific white-sided dolphins often intermix with other species, including northern right-whale dolphins, Risso's dolphins, and bottlenose dolphins. They have also been seen with gray whales and humpback whales (Leatherwood et al. 1987).

Pacific white-sided dolphins feed primarily on northern anchovy and to a lesser extent on Pacific whiting, Pacific saury, and squid (Stroud et al. 1981). Most feeding occurs at night in the epipelagic zone, and to a lesser extent in the mesopelagic zone (Leatherwood et al. 1987). This species may dive to 700-foot (210-meter) depths and remain submerged for up to 6 minutes.

In summary, the Pacific white-sided dolphin does not have a special status and it is probably the most abundant delphinid in temperate waters of the North Pacific Ocean. It is widely distributed throughout the Sea Range except for shallow and nearshore areas. The number present in the Sea Range at any time of year may be highly variable and there may be year-to-year or seasonal shifts in abundance that are related to changes in water temperature and/or changes in prey abundance. In most years, this species is abundant in the Sea Range during autumn to spring when an estimated 23,000 to 28,000 animals are present. Most Pacific white-side dolphins move northward during summer when only about 1,000 remain in the Sea Range. As many as 25,000 animals are found in non-territorial waters and as many as 9,500 in territorial waters. Mean group size in the study area is about 80 animals. Pacific white-sided dolphins feed primarily on fish at night in the epipelagic zone where they may dive to depths of 700 feet (210 meters) or more.

Risso's Dolphin, *Grampus griseus*

Risso's dolphin, or grampus, is common in the Sea Range. It is not listed under the ESA, and the stock found off California is not considered a strategic stock. There are no quantitative data regarding trends in population size in California or adjacent waters, although sightings have become more frequent in the past 20 years.

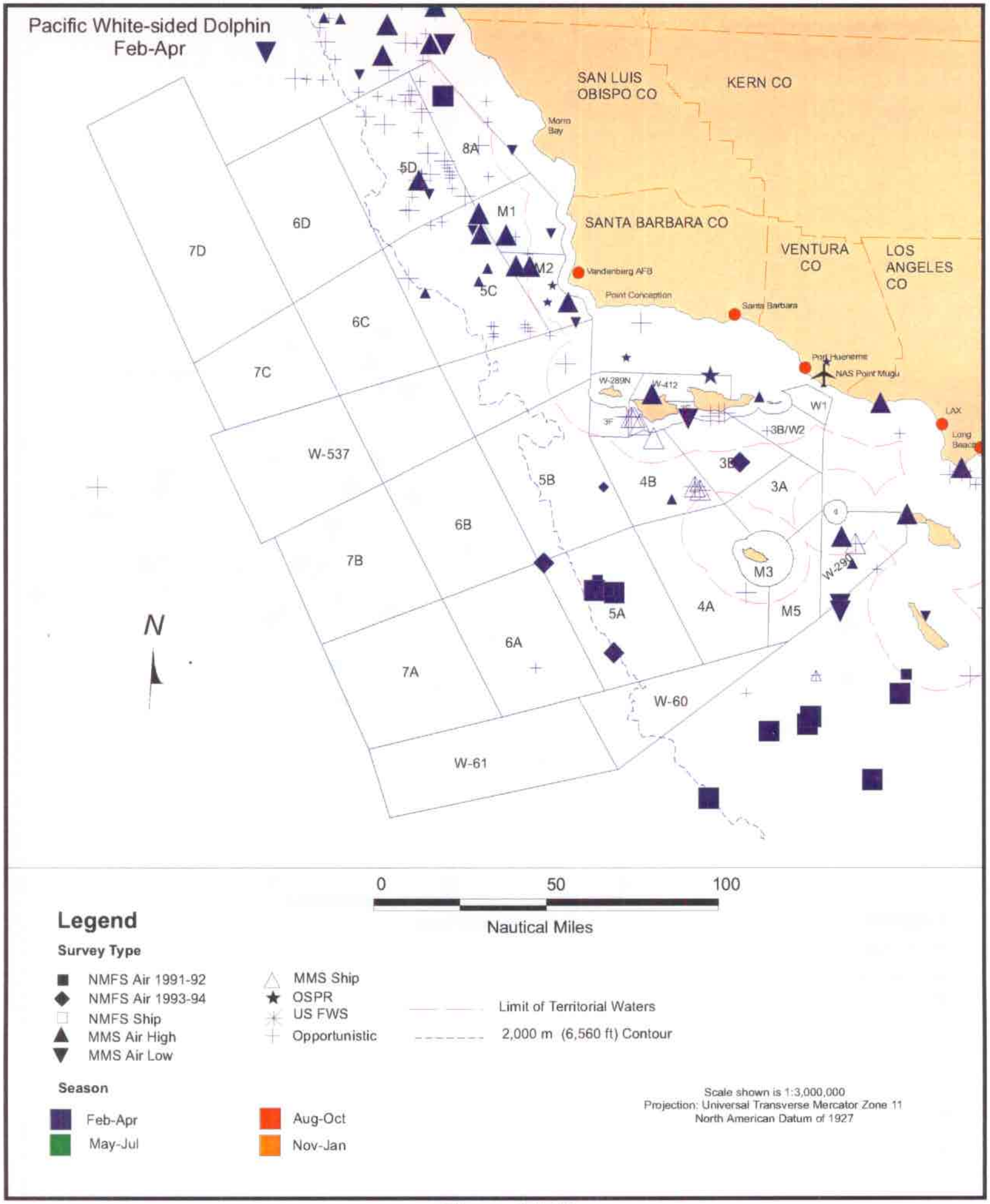


Figure 3.7-15
Sightings of Pacific white-sided dolphins during the February-April 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

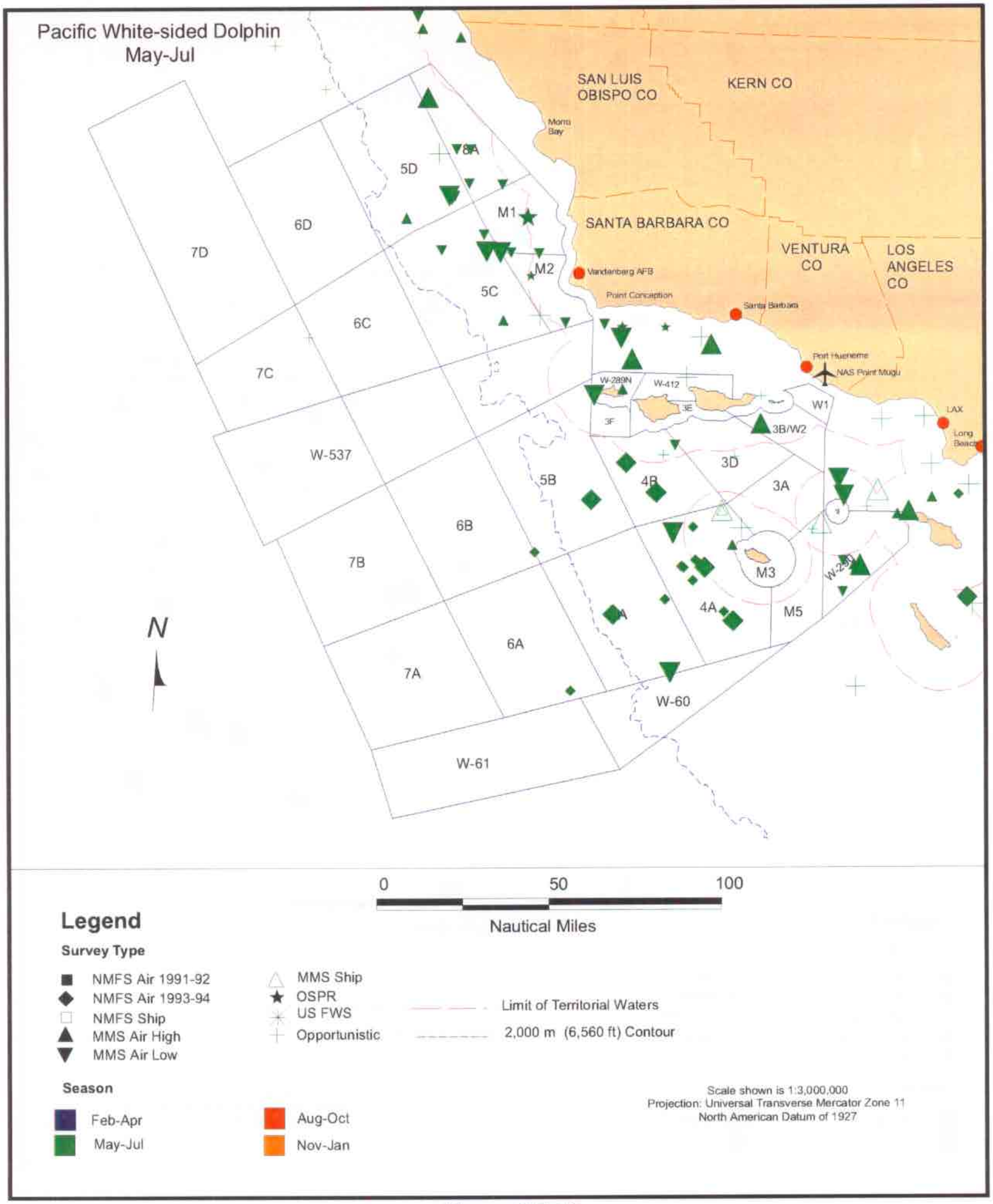


Figure 3.7-16
Sightings of Pacific white-sided dolphins during the May-July 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

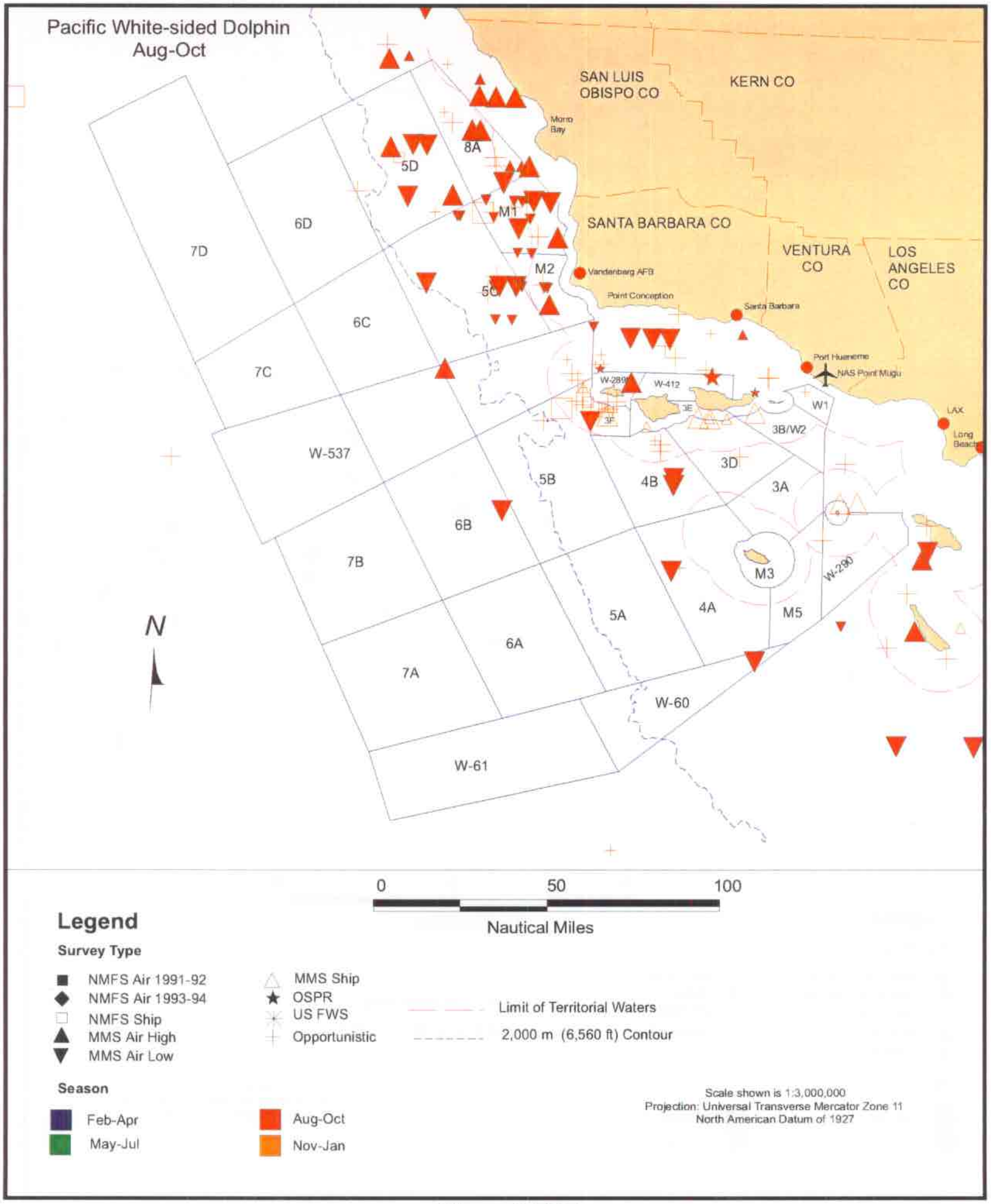


Figure 3.7-17
Sightings of Pacific white-sided dolphins during the August-October 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

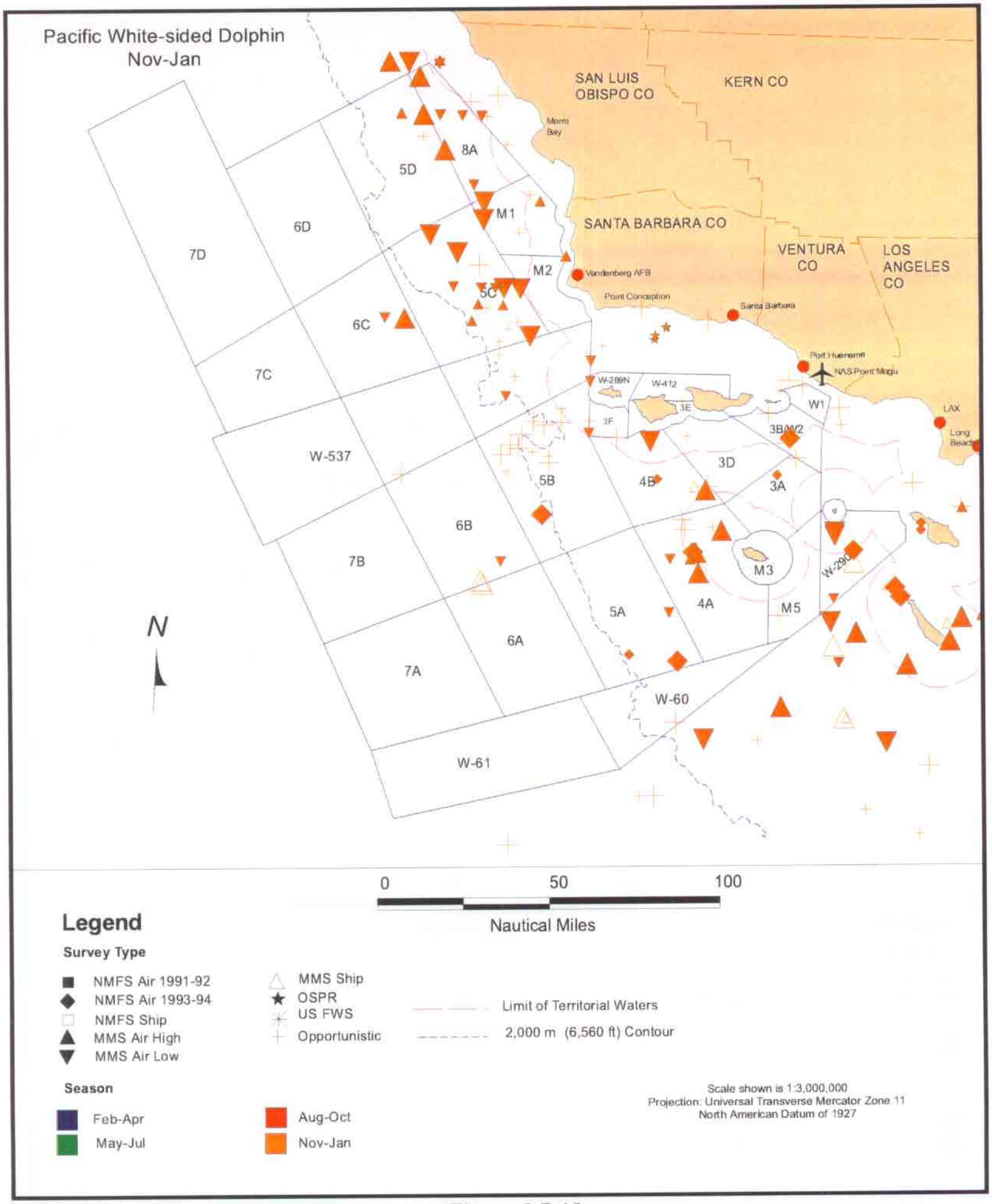


Figure 3.7-18

Sightings of Pacific white-sided dolphins during the November-January 1975-96 surveys listed in Table 3.7-3.

Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

Risso's dolphin is primarily a tropical and mid-temperate species that occurs in the eastern Pacific from the Gulf of Alaska to central Chile. There is distributional evidence that the population inhabiting California, Oregon, and Washington may be distinct from populations farther south and west (Barlow et al. 1997). Off southern California, sightings of Risso's dolphins were rare from 1959 to 1975 (Leatherwood et al. 1980, 1987). However, numbers of sightings in southern California have increased greatly since then (Heyning et al. 1994; Barlow 1995; Forney et al. 1995). Until 1970, the majority of sightings off southern California were seaward of the 600-foot (180-meter) isobath. Since 1971 an increasing number of sightings have been made over the continental shelf (Leatherwood et al. 1980; Carretta et al. 1995). A comprehensive study of the distribution of Risso's dolphin in the Gulf of Mexico found that they utilized the steeper sections of the upper continental slope in waters 1,150 to 3,200 feet (350 to 975 meters) deep (Baumgartner 1997).

Risso's dolphins have been sighted throughout the Sea Range throughout the year (Figures 3.7-19 to 3.7-22). However, in most years, higher numbers are present in the Sea Range during autumn and winter than during other times of the year (Figure 3.7-23). Most sightings in the study area have been well offshore, but Risso's dolphins have also been sighted close to shore at various locations. Few Risso's dolphins have been sighted in far offshore areas, but there has been comparatively little survey effort there, and Risso's dolphins do occur there.

The best estimate of the stock size in California waters is 32,376 (CV=0.46, Forney et al. 1995) based on aerial surveys conducted during the winters of 1991 and 1992. This estimate does not include correction factors to account for animals that were submerged at the time of the survey (availability bias) and therefore is negatively biased. Most of the California population is within the Sea Range during autumn (approximately 41,865 animals) and winter (40,536 animals) based on the procedure described above in Section 3.7.1.5, which does include allowance for submerged animals. Given the negatively-biased estimate of the overall California population size and the seasonal distribution shown in Figures 3.7-19 and 3.7-22, a small but significant proportion of the population probably occurs south of the Sea Range during those periods. During spring and summer, when some Risso's dolphins move as far north as Washington, approximately 11,645 (summer) to 14,761 (spring) are found in the Sea Range.

Of the Risso's dolphins in the Sea Range, an estimated 75 to 8,272 occur in territorial waters. These represent 0.5 percent of the spring population of the Sea Range, and 20 percent of the winter population (Table 3.7-5). The estimated numbers in non-territorial waters range from 7,034 (60 percent) to 40,647 (97 percent) during summer and autumn, respectively.

Risso's dolphins occur in small to moderate-sized groups, normally ranging in numbers from one to less than 250. The majority of groups contain fewer than 50 (Leatherwood et al. 1980; Carretta et al. 1995). One group of 2,500 animals was seen within the Sea Range in Range Area 4A southwest of San Nicolas Island in April. The mean size of 320 groups sighted within the Sea Range was 42 animals. Excluding the five largest groups, the mean group size was 25. Risso's dolphins are gregarious and are often sighted with northern right-whale dolphins and pilot whales (Leatherwood et al. 1987). However, Shane (1995) suggested that competitive displacement may prevent co-occurrence of Risso's dolphins with pilot whales in areas with limited food resources. Risso's dolphins feed almost exclusively on squid (Orr 1966; Leatherwood et al. 1987; Shane 1995).

There is little information on the sex and age composition of the Risso's dolphin population within the Sea Range, but Bonnell and Dailey (1993) note that immature animals have been sighted at all times of year in the SCB.

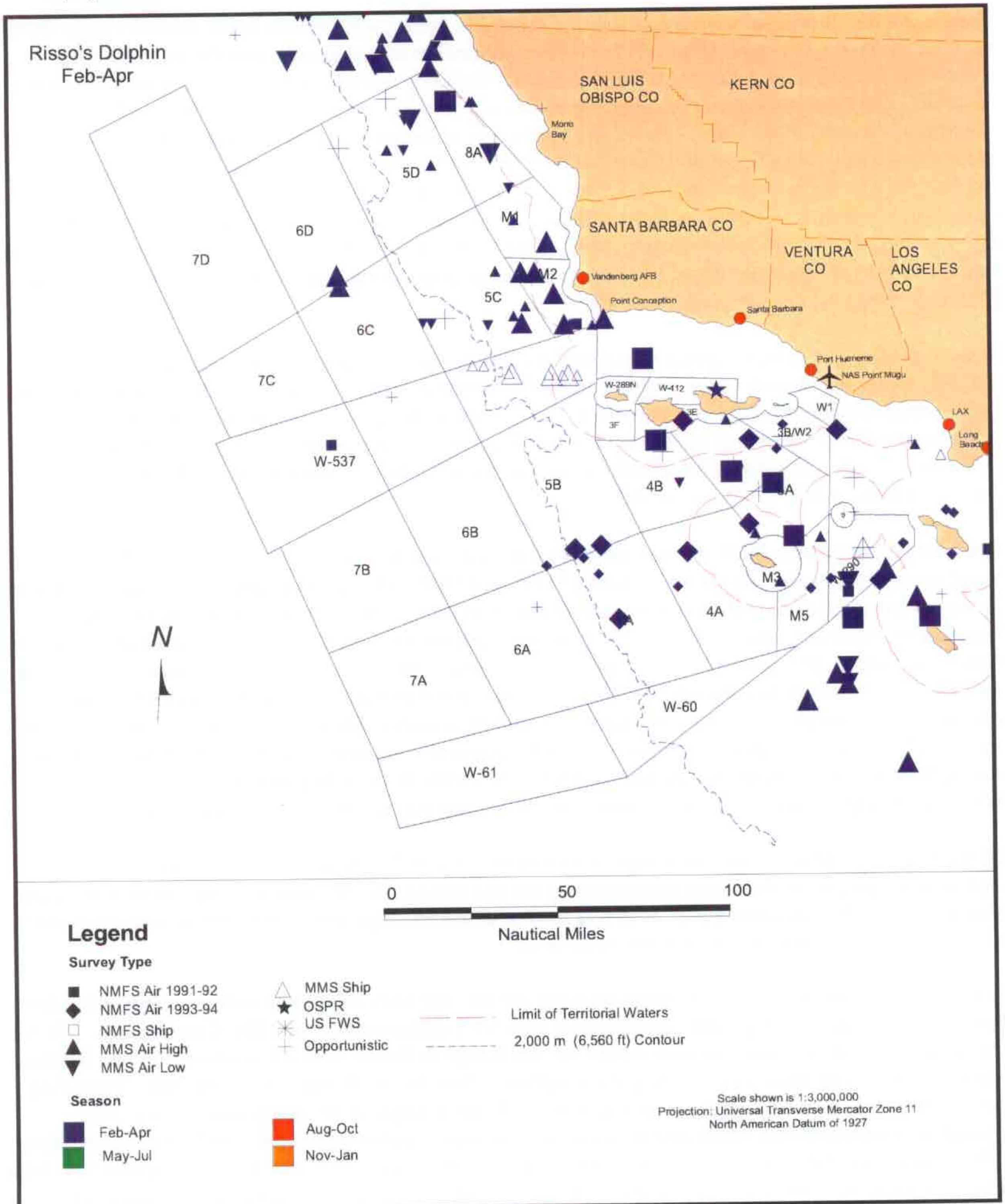


Figure 3.7-19

Sightings of Risso's dolphins during the February-April 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

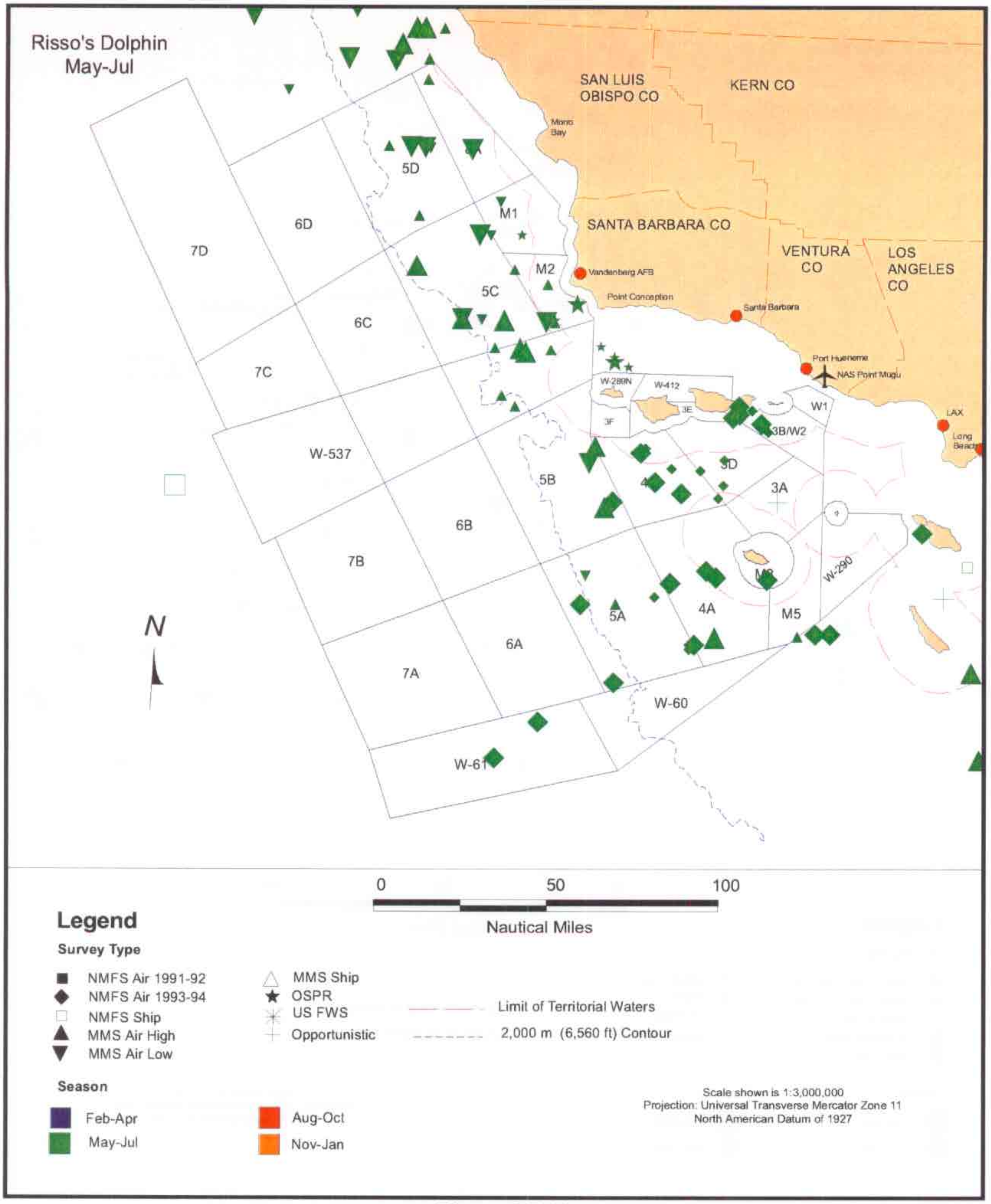


Figure 3.7-20

Sightings of Risso's dolphins during the May-July 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

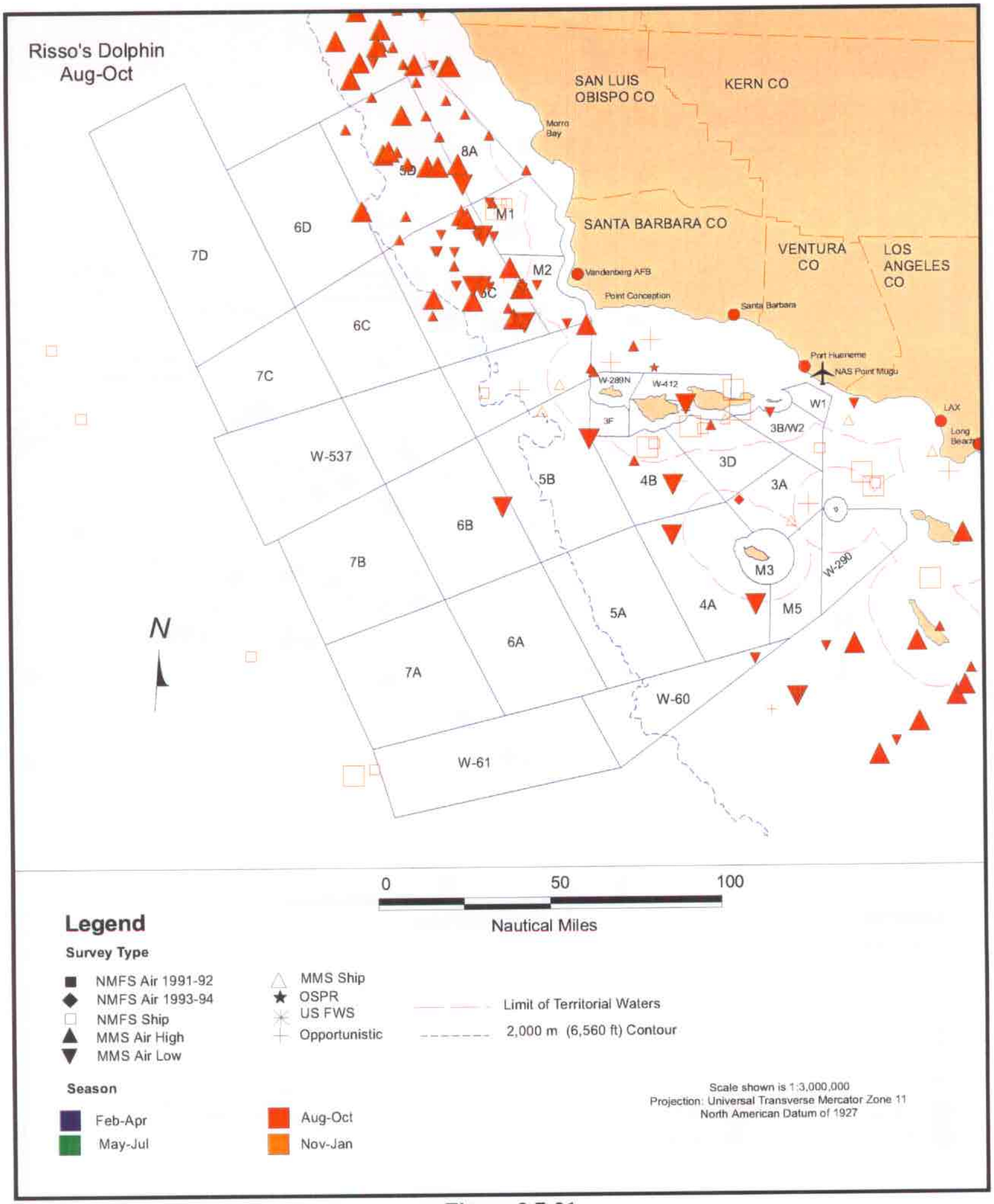


Figure 3.7-21

Sightings of Risso's dolphins during the August-October 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

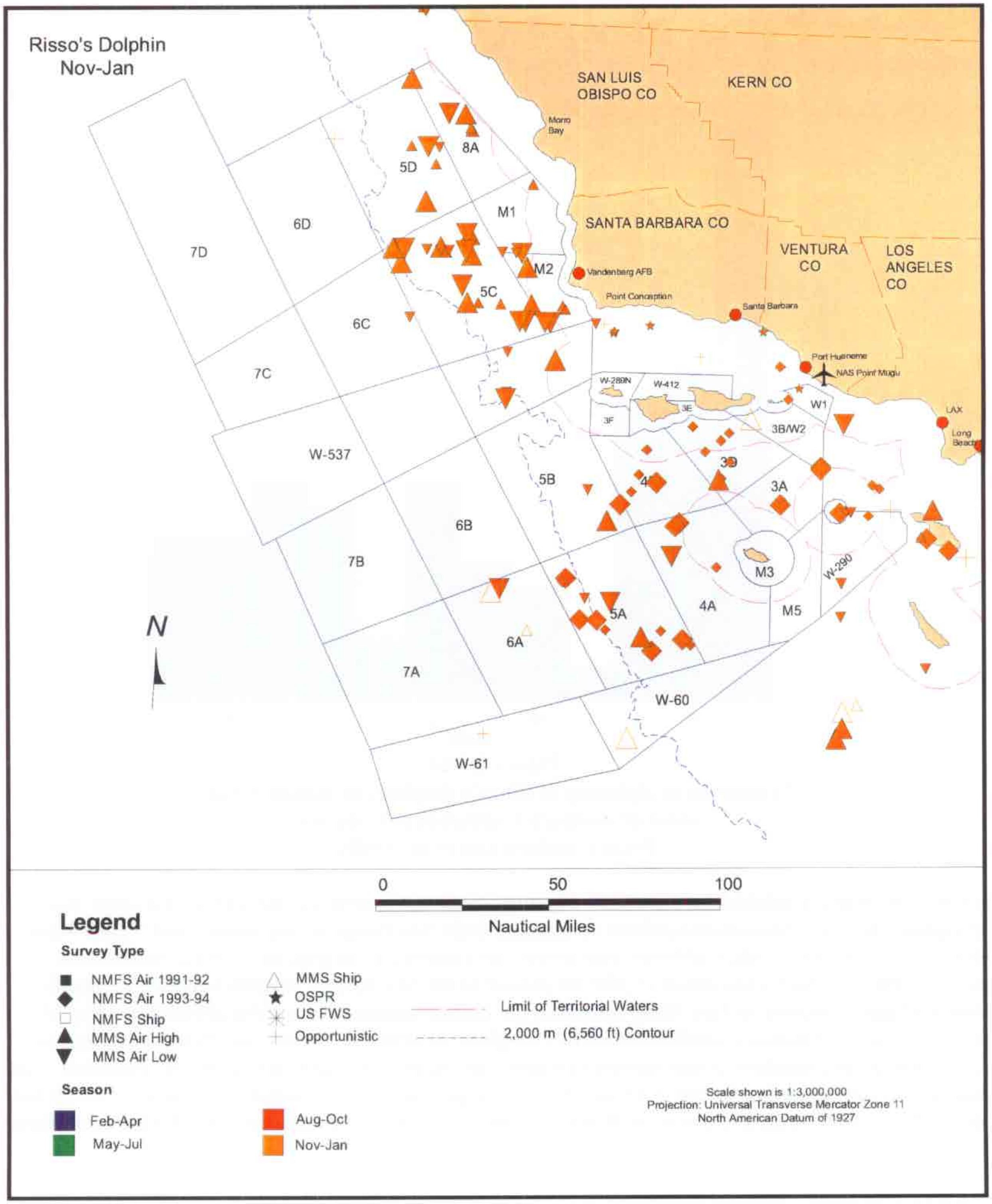


Figure 3.7-22

Sightings of Risso's dolphins during the November-January 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

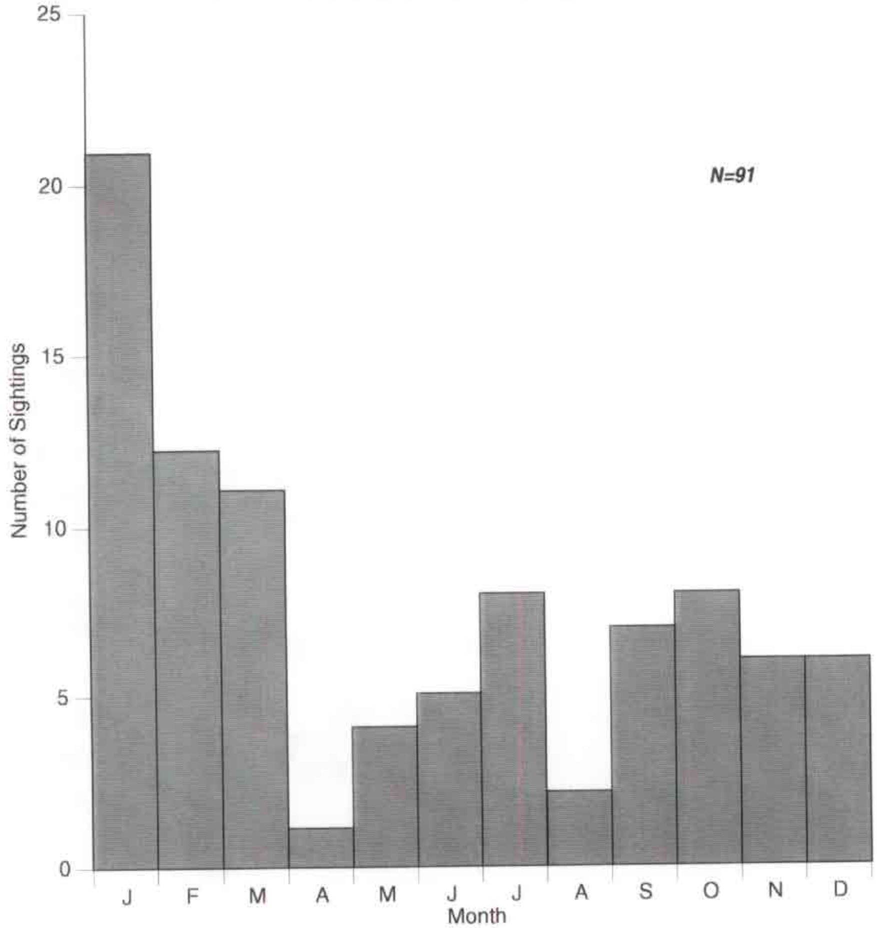


Figure 3.7-23
Frequency of sightings of Risso's dolphins by month off the coast of southern California and Mexico. From Leatherwood et al. (1980).

In summary, Risso's dolphin does not have a special status and is common throughout the range and throughout the year. Maximum numbers are present in the Sea Range during autumn and winter when about 32,000, or most of the California population, are expected to be present. Lowest numbers are present during summer when about 11,600 are present in the Sea Range. Numbers present in specific areas are highly variable and are likely related to sea surface temperature and the abundance of squid, their major prey. Estimated numbers of Risso's dolphins in territorial waters vary from 75 (spring) to 8,272 (winter) and numbers in non-territorial waters vary from 7,034 (summer) to 40,647 (autumn). The mean group size in the Sea Range is 42 (or 25 if five large groups are excluded); one group of 2,500 has been sighted. Both adult and immature Risso's dolphins are likely to occur in the Sea Range at all times of year.

Bottlenose Dolphin, *Tursiops truncatus*

The bottlenose dolphin is not listed as endangered under the ESA or as depleted under the MMPA, and individuals that occur in the Sea Range do not belong to a strategic stock. There are no available data regarding trends in abundance in California or adjacent waters. However, the small southern California coastal stock of bottlenose dolphins could be vulnerable to activities that might alter its population size.

Bottlenose dolphins are distributed world-wide in tropical and warm-temperate waters. In southern California two populations occur: a coastal population within 0.5 NM (0.9 kilometers) of shore and a larger offshore population (Hansen 1990).

The coastal population of bottlenose dolphins inhabits waters from Point Loma to San Pedro (Dohl et al. 1981; Hansen 1990). Occasionally, during warm-water incursions, their range extends farther north. During the El Niño event of 1982 to 1983, sightings of coastal bottlenose dolphins were made as far north as Monterey Bay (Wells et al. 1990). Following the El Niño event, they continued to use waters north of their normal range. From 1983 to 1988 coastal bottlenose dolphins were sighted 64 times north of Point Conception and on three occasions between Ventura and Santa Barbara (Wells et al. 1990). No coastal bottlenose dolphins have been identified within the Sea Range, although sightings are common along the coast east of the Sea Range (Barlow et al. 1997).

The best estimate of stock size of the coastal stock of bottlenose dolphins in California is 140 individuals (CI=127 to 154) (Carretta et al. 1998). This estimate is based on replicated surveys and is corrected for animals missed by each survey team. This procedure should account for the diving behavior of coastal bottlenose dolphins. However, this estimate is still conservative because areas north of Point Conception and south of California were not included in the estimate. Some animals from this stock may have been present in both of these areas. None of these 140 animals are expected to occur normally in the Sea Range.

Offshore bottlenose dolphins are thought to have a continuous distribution in California (Mangels and Gerrodette 1994). They have been found in the SCB and in waters as far north as about 41° north latitude (Barlow et al. 1997). During most of the year, a relatively large population of bottlenose dolphins occurs in offshore waters of the SCB, centered around Santa Catalina Island, southeast of the Sea Range (Figure 3.7-24). The population may disperse more broadly in summer than in winter (Dohl et al. 1981; Figure 3.7-24).

The best estimate of abundance of offshore bottlenose dolphins in California waters is 2,555 (CV=0.36) based on a weighted average of recent aerial and shipboard surveys (Barlow et al. 1997). This estimate is not corrected to account for the diving behavior of bottlenose dolphins, and therefore is negatively biased. Many of these animals are either along the coast east of the Sea Range or in nearshore waters southeast of the Sea Range. The estimation procedure described in Section 3.7.1.5 provides estimates of 534, 0, 2,942, and 949 bottlenose dolphins in the Point Mugu Sea Range during winter, spring, summer, and autumn, respectively. Most of these animals would be found in the southeast part of the Sea Range. The summer estimate is probably overestimated and the spring estimate is probably underestimated. During summer, an estimated 60 percent (1,776) of the bottlenose dolphins present in the Sea Range are in territorial waters and 40 percent (1,166) are in non-territorial waters. During winter all of the estimated 534 animals in the Sea Range are in non-territorial waters. During autumn, 57 percent are in non-territorial waters while 43 percent (409) are in territorial waters.

Group sizes of bottlenose dolphins commonly vary from one to 20 animals and the mean size of 24 groups sighted within the Sea Range was 15 animals. The largest group seen within the Sea Range was 60 animals. This species eats a wide variety of fish, squid, shrimp, and crab species (Bonnell and Dailey 1993). The most commonly eaten fish species were queenfish, white croaker, walleye, surfperch, and plainfin midshipman. Most of these prey (68 percent) are benthic feeders, and nearly all are regular inhabitants of middle to bottom depths (Hanson and Defran 1993).

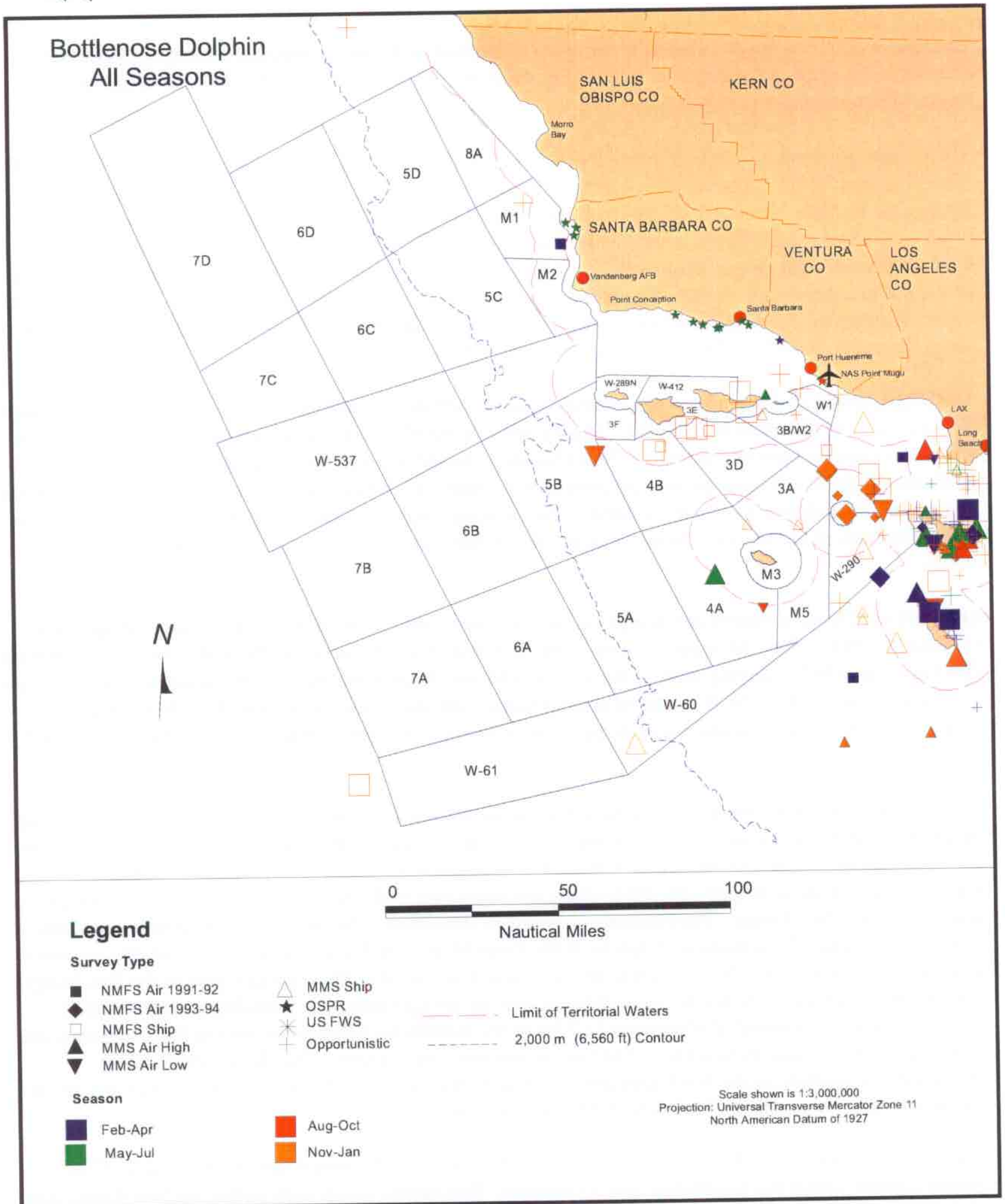


Figure 3.7-24

Sightings of bottlenose dolphins during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

In summary, there are two stocks of bottlenose dolphins in and near the Sea Range: a coastal stock and an offshore stock. Neither stock has a special status but the coastal stock is small and is vulnerable to any population declines. Coastal bottlenose dolphins have not been identified within the Point Mugu Sea Range although they are commonly sighted in coastal and nearshore areas east and southeast of the Sea Range. Offshore bottlenose dolphins are present year-round but are more abundant during summer, when approximately 2,942 dolphins are present. Highest densities of bottlenose dolphins are found in the southeastern part of the Sea Range. During summer about 60 percent of the bottlenose dolphins in the Sea Range are found in territorial waters. During other times of the year, they are probably more common in non-territorial than territorial waters. Bottlenose dolphins are opportunistic feeders that regularly forage near the bottom on fish.

Common Dolphin, *Delphinus* spp.

The common dolphin is very common in the Sea Range. This species is not listed under the ESA, and animals inhabiting waters off the coast of California are not considered to be part of a strategic stock. Available data regarding trends in population size in California and adjacent waters suggest an increase in abundance of both the short-beaked and long-beaked forms, likely because of gradual warming of waters off California (Heyning and Perrin 1994; Barlow et al. 1997; Forney 1997).

Common dolphins are widely distributed world-wide in tropical to warm temperate waters (Jefferson et al. 1993). Stocks found off the California coast are distributed from about 13° N to 42° N. Two species of common dolphins occur off California, the more coastal long-beaked dolphin (*D. capensis*) and the more offshore short-beaked dolphin (*D. delphis*). The long-beaked common dolphin is less abundant and only recently has been recognized as a separate species (Heyning and Perrin 1994). Thus much of the available information has not differentiated between the two forms.

Short-beaked common dolphins are widely distributed between the coast and at least 300 NM from shore in the eastern North Pacific (Barlow et al. 1997). In comparison, all sightings of the long-beaked form have been within about 100 NM (185 kilometers) of shore (Perrin et al. 1985; Barlow 1992 *in* Heyning et al. 1994), and most have been within 50 NM (Barlow et al. 1997). Distributions of both forms overlap in nearshore waters of the eastern Pacific (Perrin et al. 1985 *in* Heyning et al. 1994).

The abundance of common dolphins has been shown to change on both seasonal and inter-annual time scales in southern California (Dohl et al. 1986; Barlow 1995; Forney et al. 1995). This is probably related to movements northward in spring and summer as water temperatures rise, and southward in autumn as water temperatures drop. In the 1970s and 1980s, common dolphin abundance was shown to peak in summer and autumn while lower numbers were seen in winter and spring (Figure 3.7-25, Dohl et al. 1986). This pattern is evident on maps that combine sightings from studies (including the Dohl et al. 1986 study) from 1975 to 1996 (Figures 3.7-26 to 3.7-29). Mean sighting rates during SWFSC surveys in the OSTR (Outer Sea Test Range; Figure 3.7-4) in 1993 to 1994 were 6.43 and 0.92 groups per 1,000 NM (3.48 and 0.50 per 1,000 kilometers) during June to August and during December to February, respectively (Table 3.7-6). Other recent studies, however, indicate that the distribution of common dolphins has changed and there have been dramatic increases in numbers in the Sea Range during all seasons (Barlow 1995; Forney et al. 1995; Forney 1997). The largest increases have occurred during autumn to spring, with lower increases during summer when many animals move north of the Sea Range as far as 40° north latitude (Hill and Barlow 1992; Mangels and Gerrodette 1994).

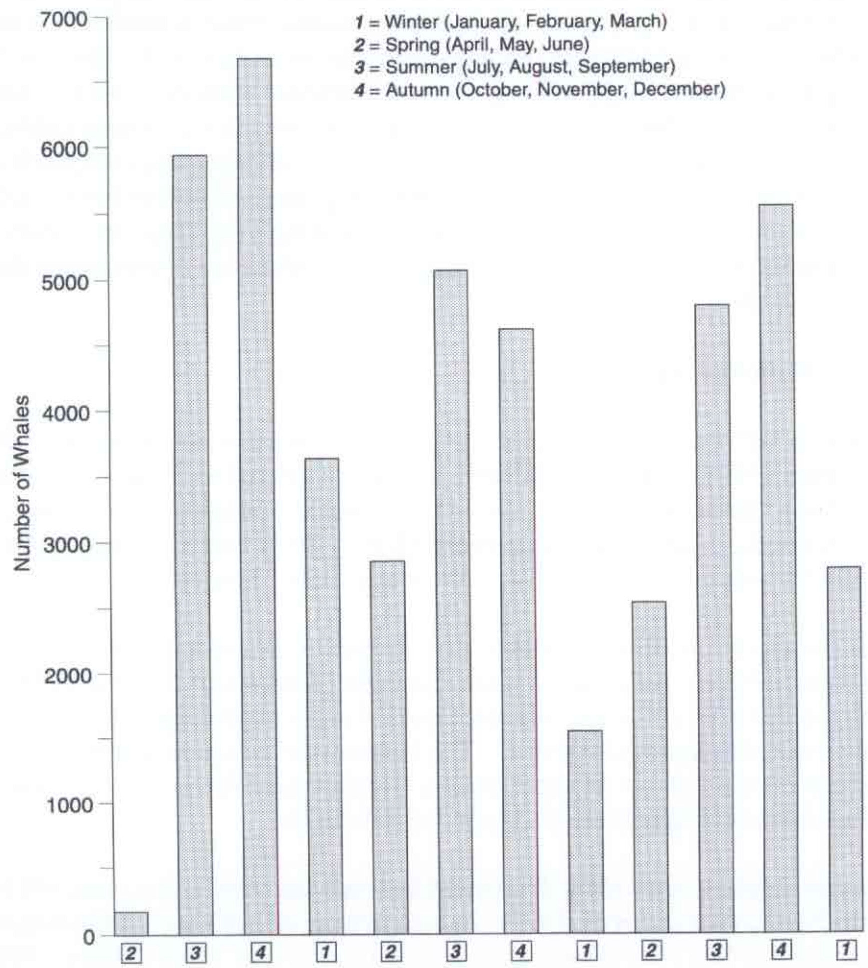


Figure 3.7-25
Quarterly counts of common dolphins during aerial surveys in the Southern California Bight from April 1975 to March 1978.
Year 1 is from April 1975 to March 1976 etc. From Dohl et al. (1981).

The common dolphin is the most abundant cetacean in the Point Mugu Sea Range. There were a total of 417 sightings of 58,770 individuals in the Sea Range during the studies summarized here, plus an additional 110 sightings of 33,630 animals in adjacent areas east of the range. As noted above, the distribution and abundance of this species changes in the Sea Range during the year.

The best abundance estimates for both species of common dolphins in California waters are

- 372,425 (CV=0.22) for short-beaked common dolphins and
- 8,980 (CV=0.64) for long-beaked common dolphins.

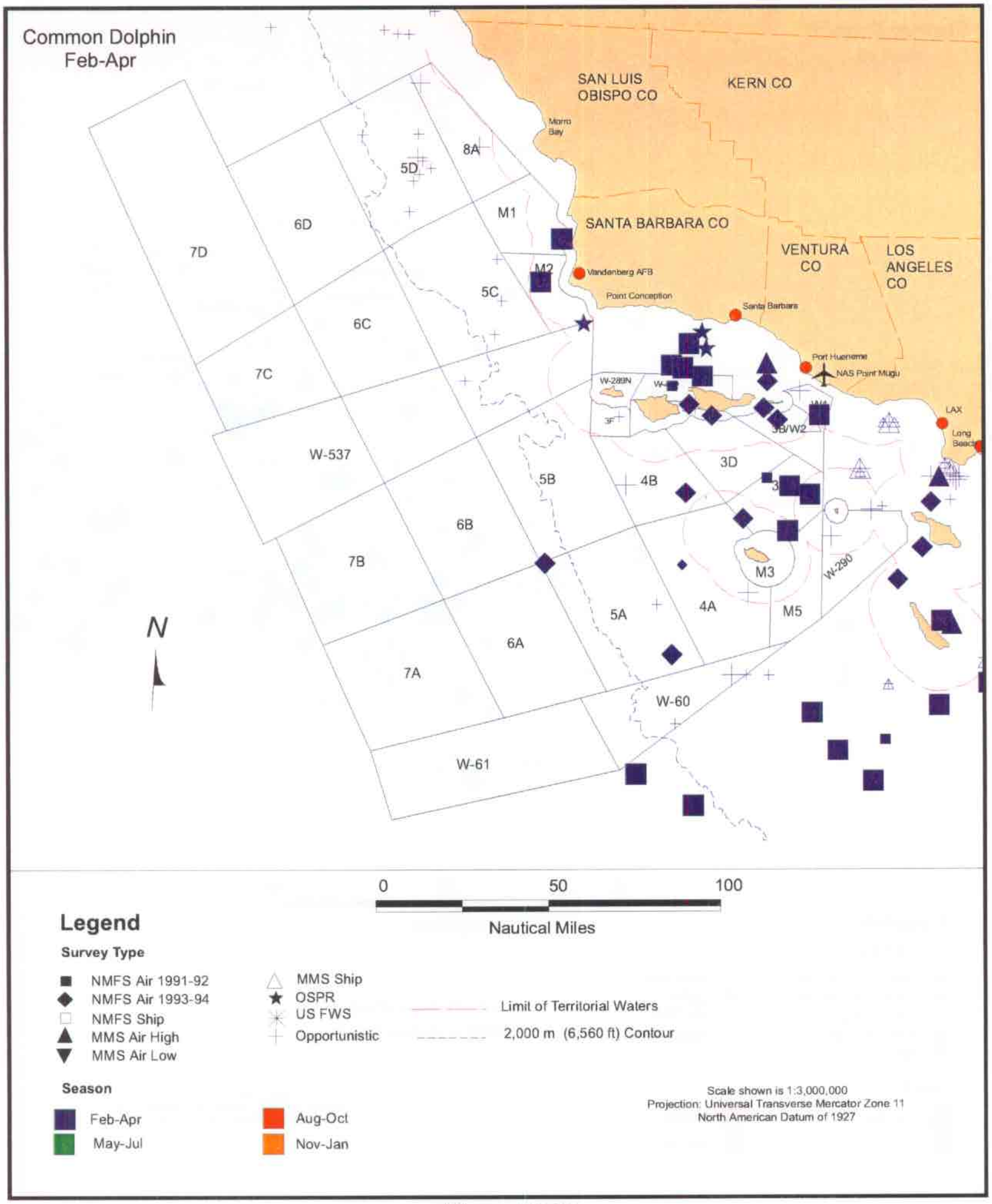


Figure 3.7-26

Sightings of common dolphins during the February-April 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-20 animals vs. 21 or more animals, respectively.

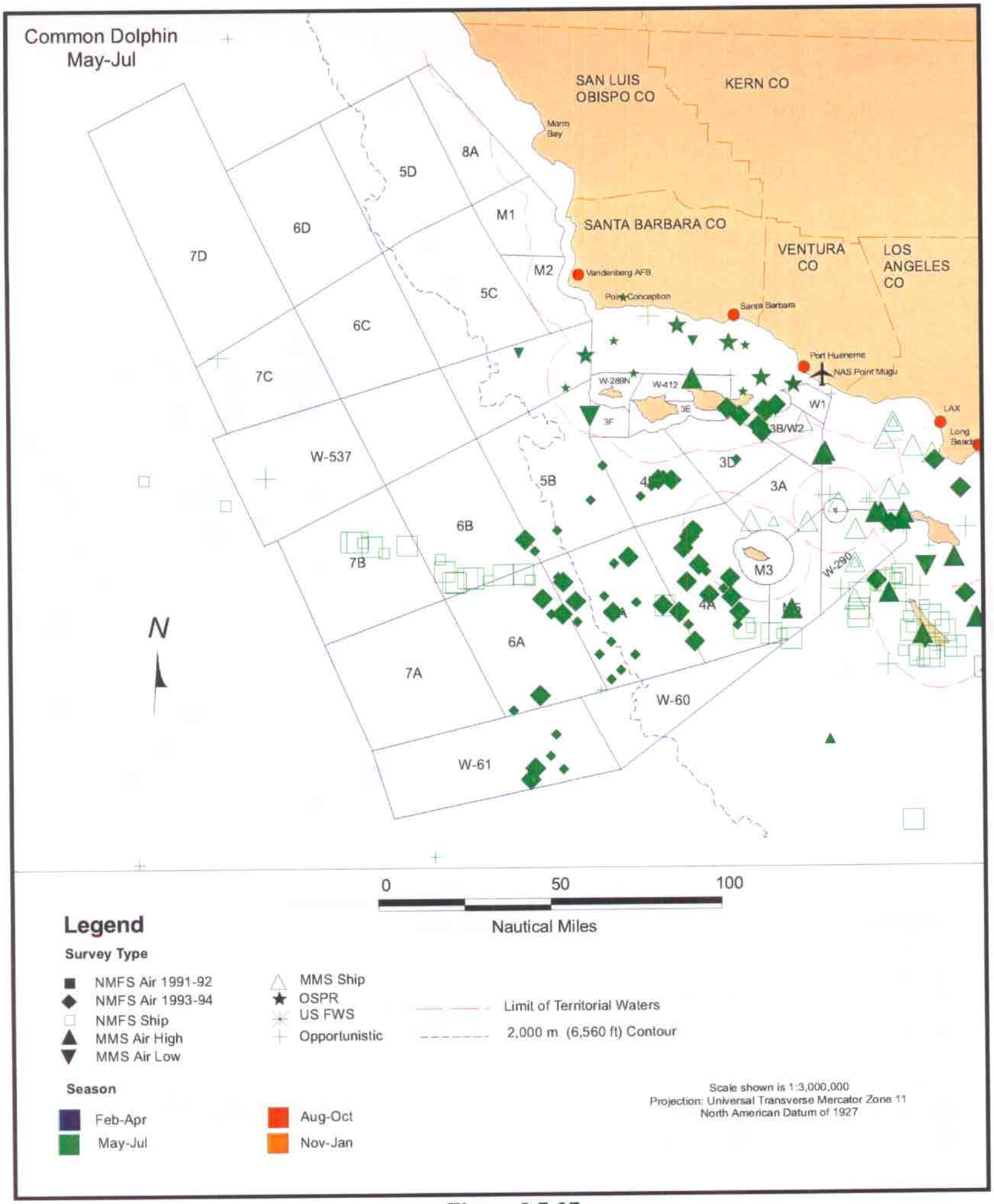


Figure 3.7-27

Sightings of common dolphins during the May-July 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-20 animals vs. 21 or more animals, respectively.

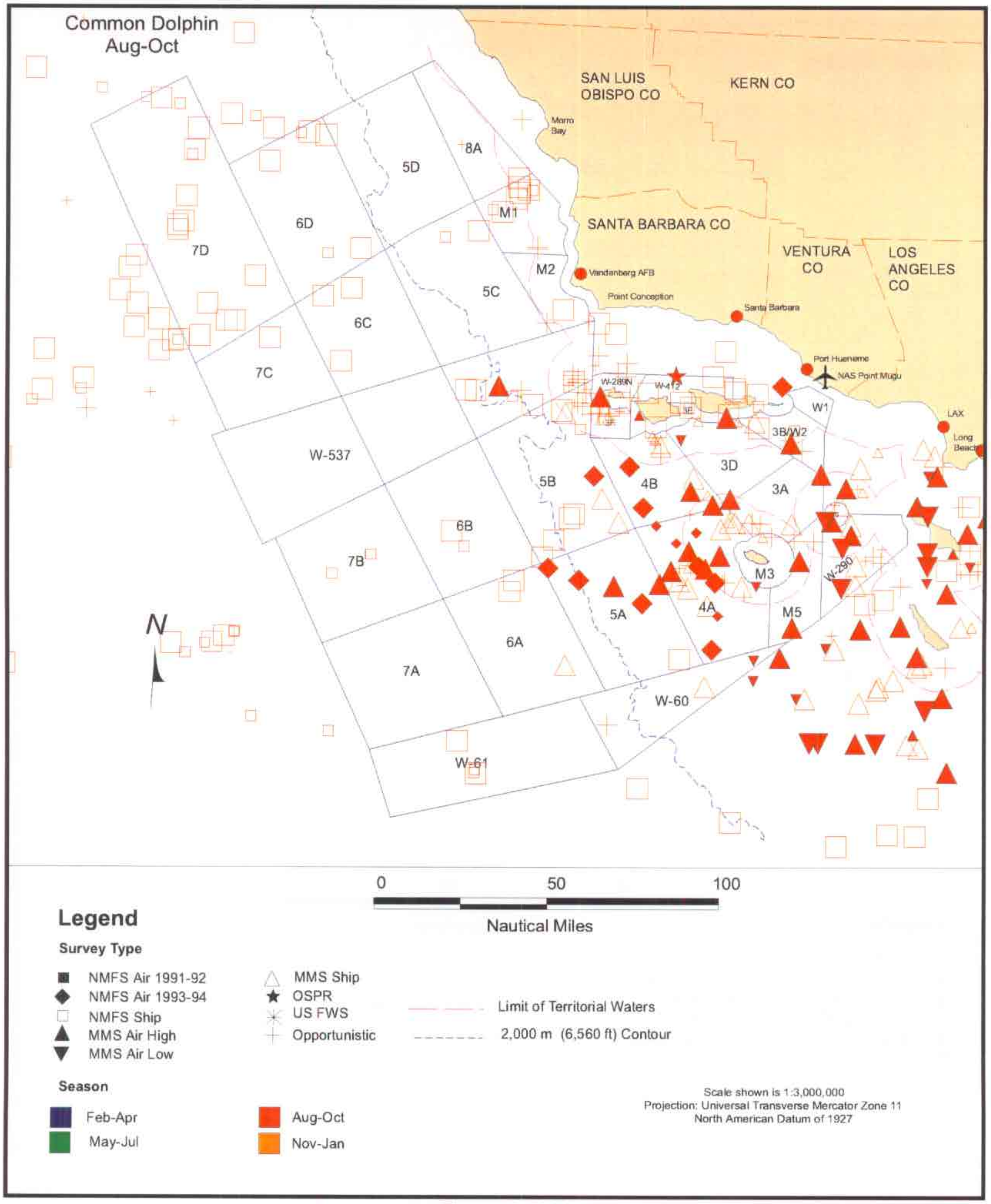


Figure 3.7-28

Sightings of common dolphins during the August-October 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-20 animals vs. 21 or more animals, respectively.

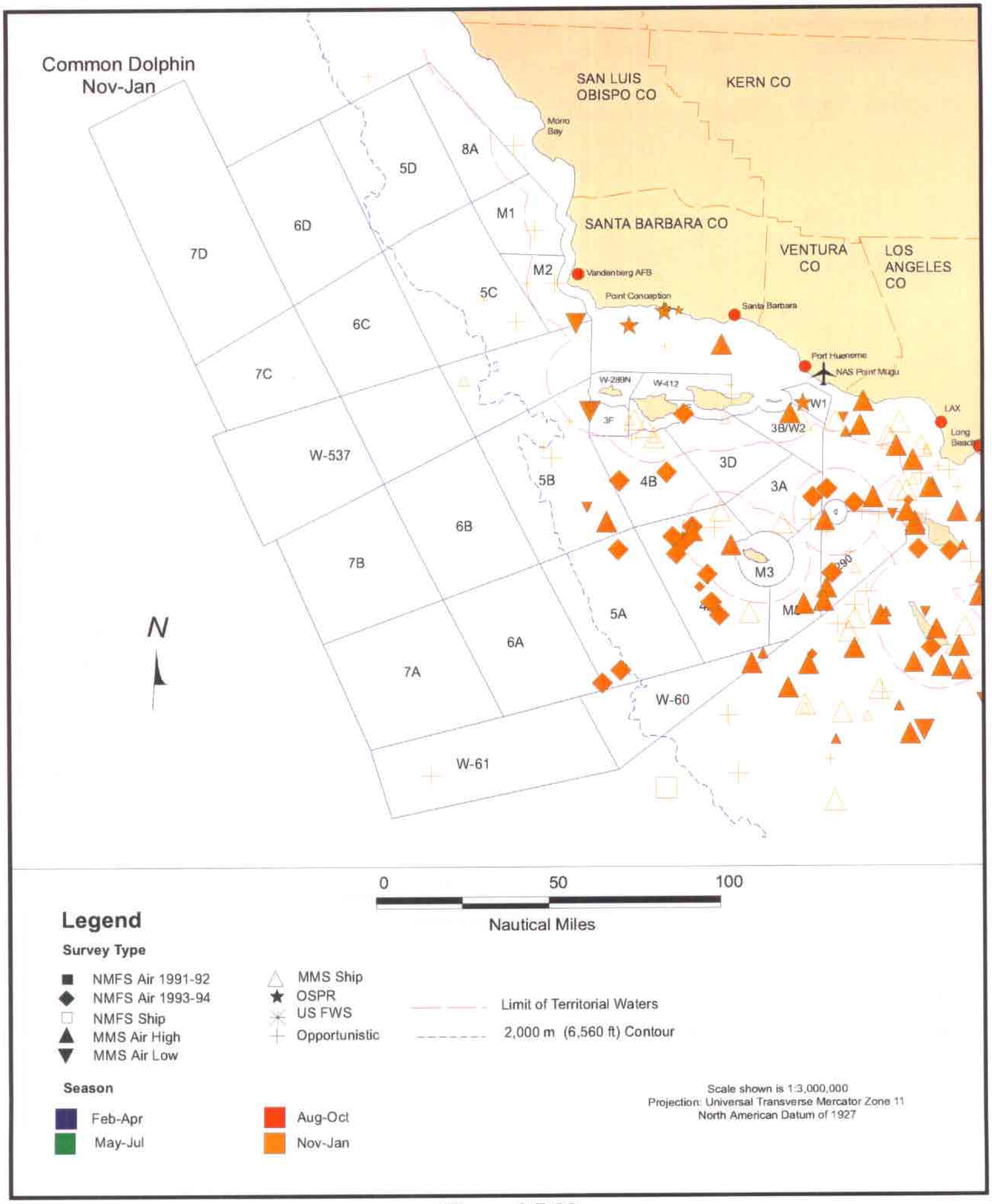


Figure 3.7-29

Sightings of common dolphins during the November-January 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-20 animals vs. 21 or more animals, respectively.

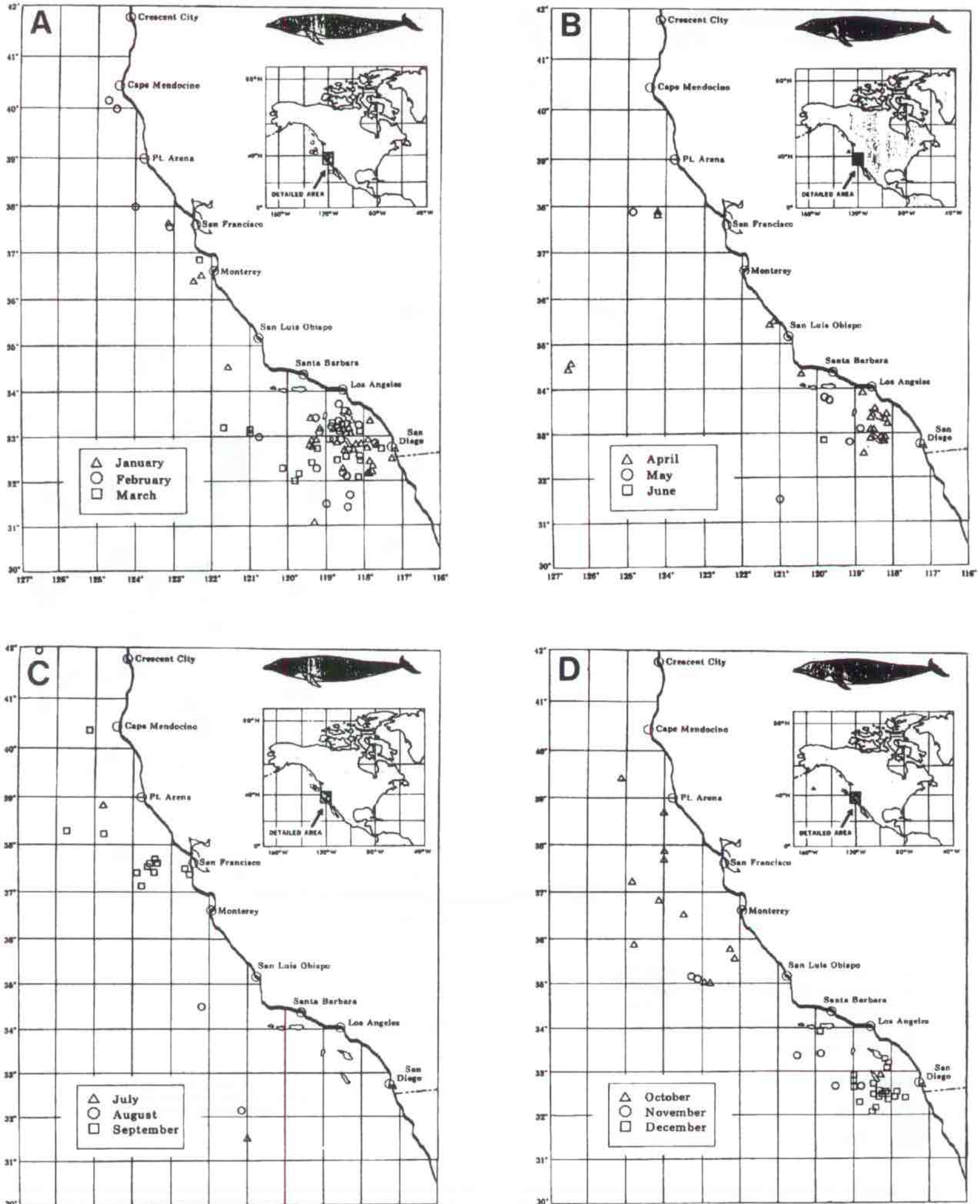


Figure 3.7-30
Approximate locations of sightings of northern right whale dolphins during aerial surveys conducted during *(A)* winter, *(B)* spring, *(C)* summer, and *(D)* fall, 1968-76. From Leatherwood and Walker (1979).

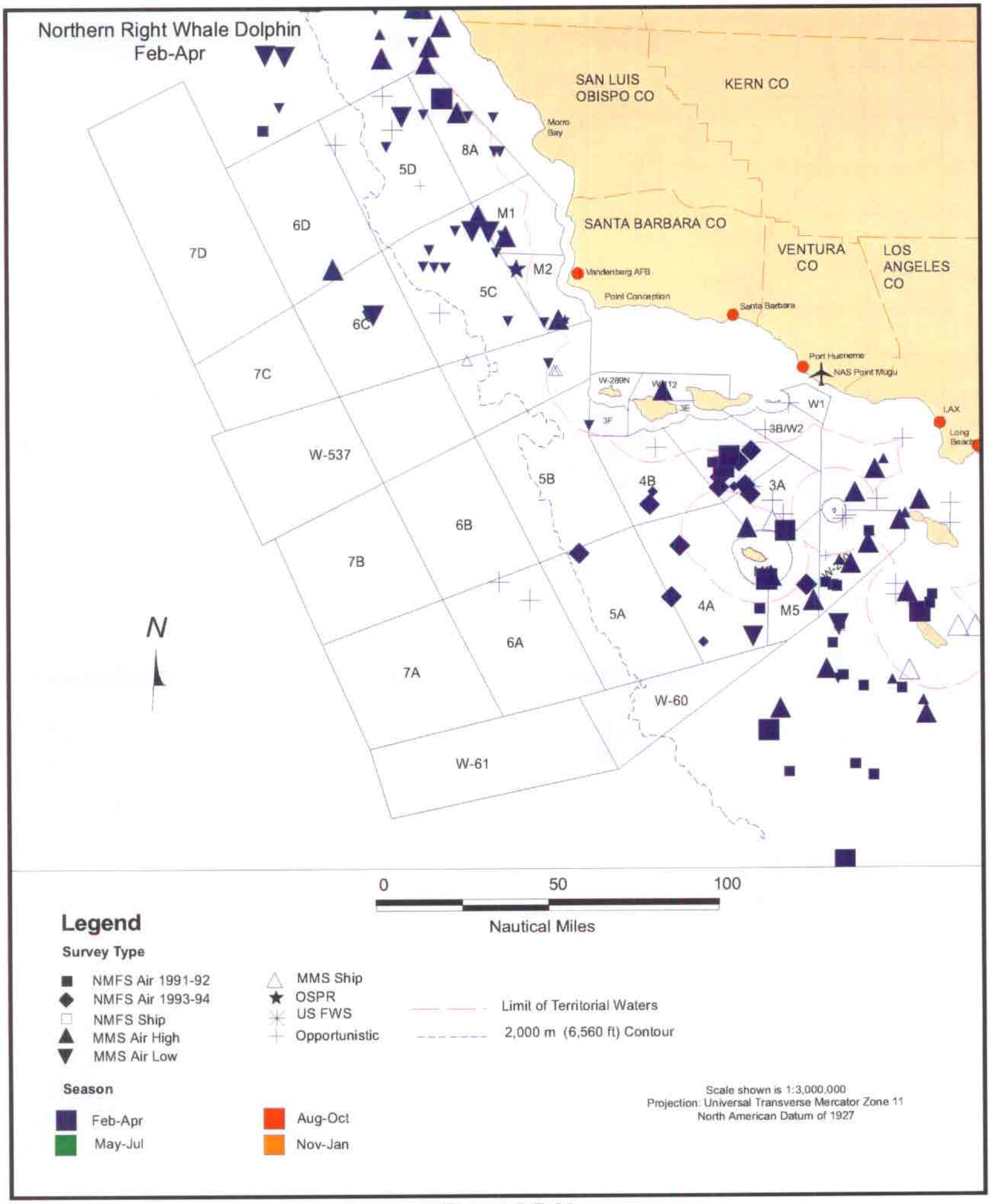


Figure 3.7-31
Sightings of northern right whale dolphins during the February-April 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

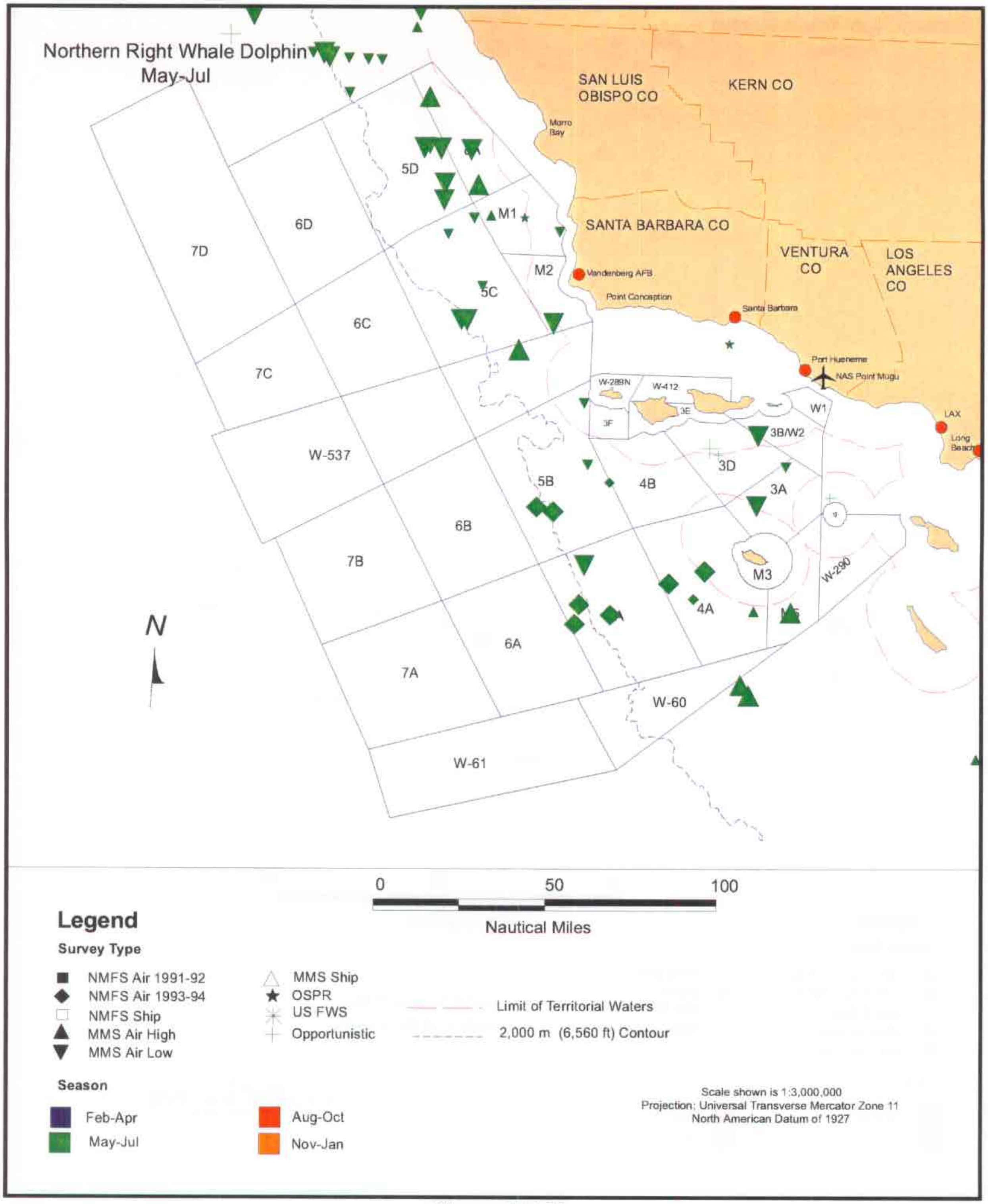


Figure 3.7-32
Sightings of northern right whale dolphins during the May-July 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

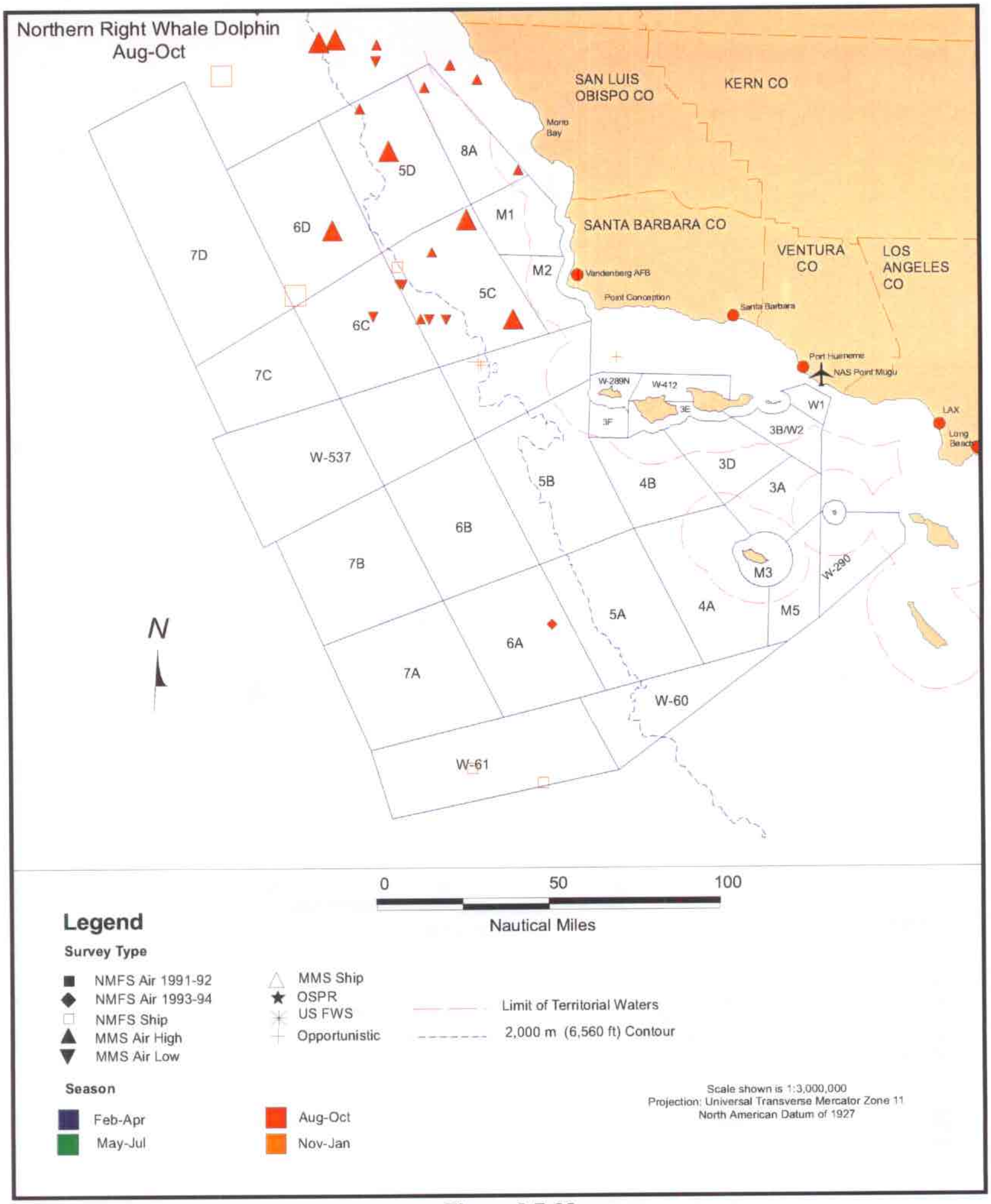


Figure 3.7-33
Sightings of northern right whale dolphins during the August-October 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

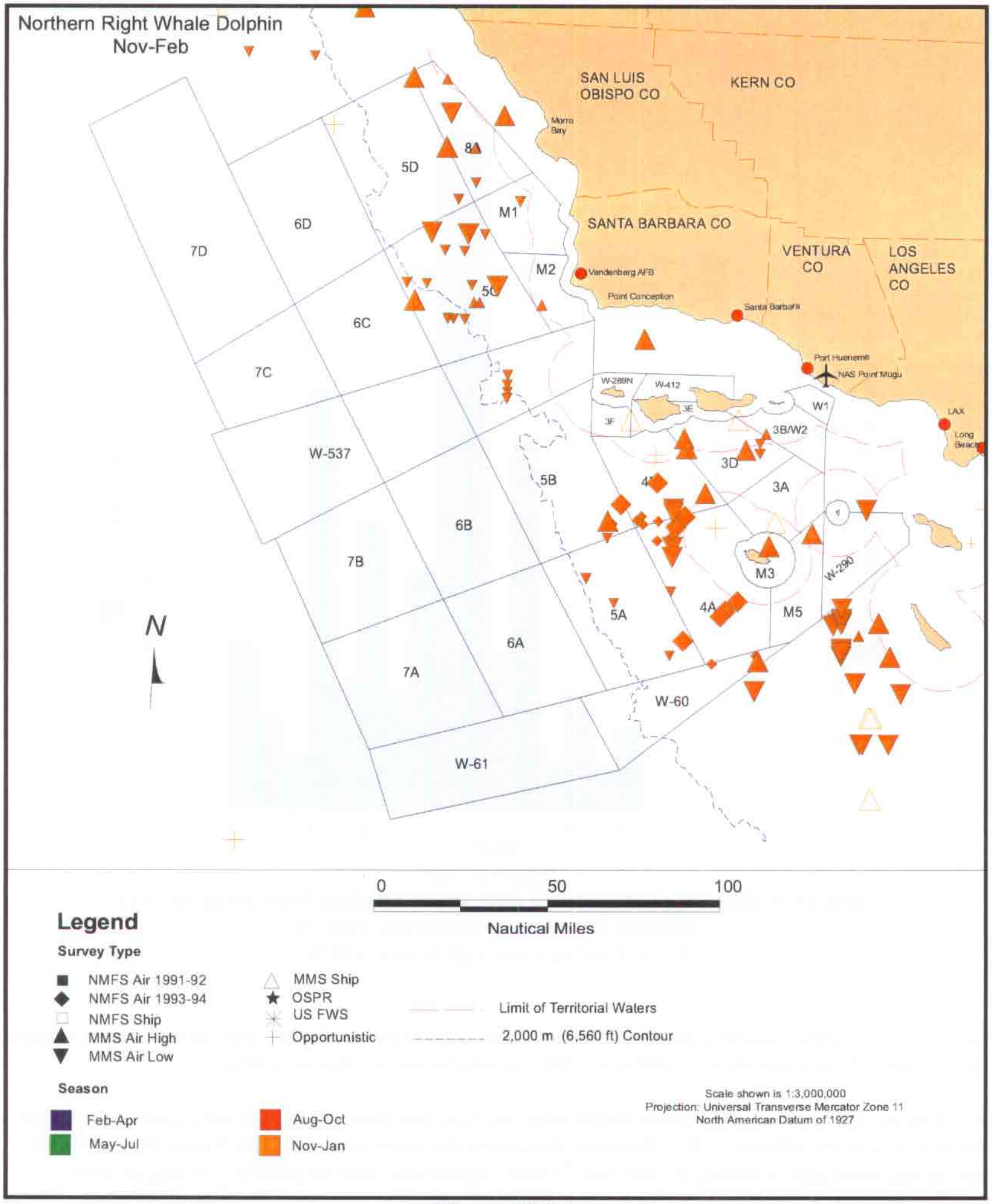


Figure 3.7-34
Sightings of northern right whale dolphins during the November-January 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-10 vs. 11 or more animals, respectively.

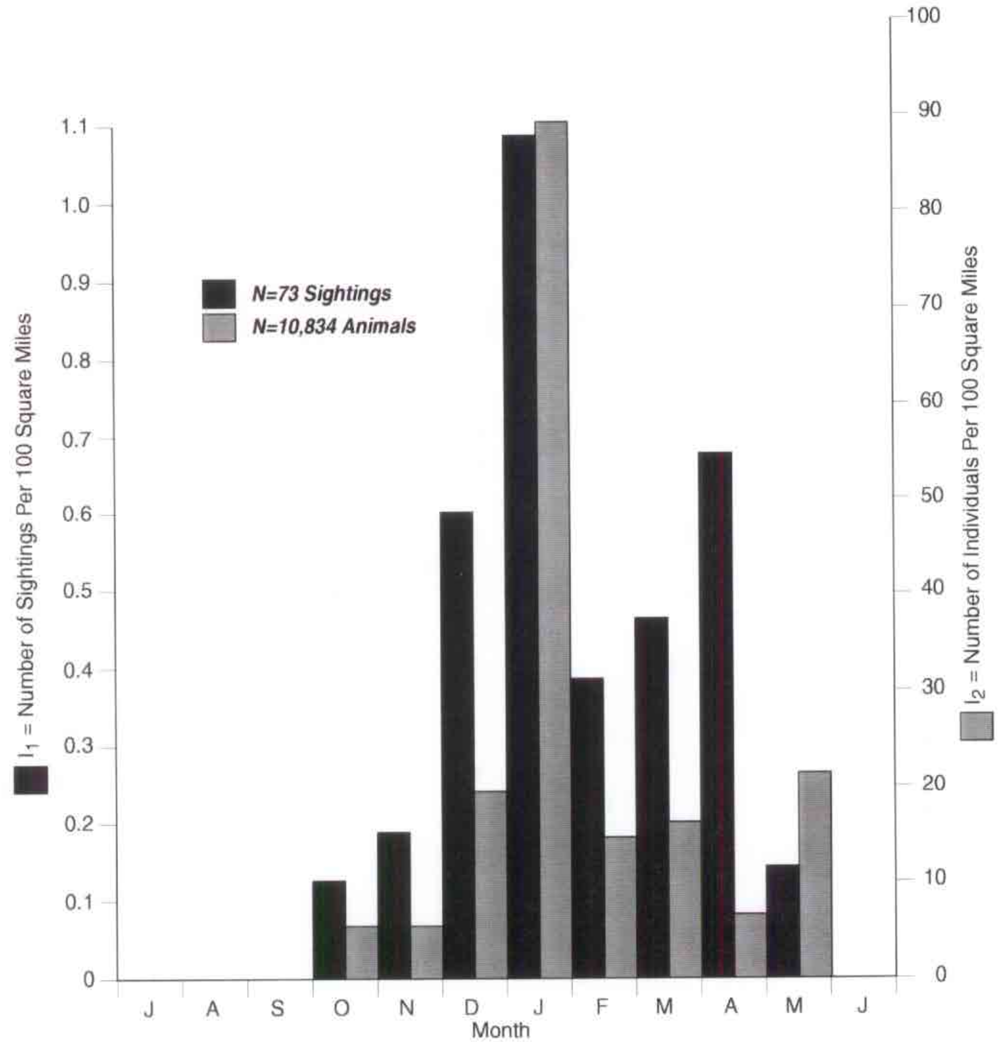


Figure 3.7-35
Indices of abundance of northern right whale dolphins from aerial surveys offshore of southern California, 1968-76.
From Leatherwood and Walker (1979).

Northern right whale dolphins feed primarily on squid, lanternfish, and other mesopelagic fish at depths less than 990 feet (300 meters) (Dohl et al. 1983; Leatherwood and Reeves 1983).

In summary, the northern right whale dolphin has not been assigned any special status and the trends in population size are unknown. It is abundant throughout the inner half of the Sea Range during winter and spring when approximately 87,000 and 77,000, respectively, may be present. During autumn, smaller numbers are present in the same area; many animals have moved north of the Sea Range. During summer, only 4,000 animals are present in the Sea Range, most in the northern part. During all times of year the majority (more than 90 percent) of northern right whale dolphins are found in non-territorial waters. Mean group size within the Point Mugu Sea Range was 89 individuals (n=214) but groups of up to 2,500 animals have been seen there. Northern right whale dolphins feed on squid, lanternfish, and other mesopelagic fish at depths greater than 990 feet (300 meters).

Short-finned Pilot Whale, *Globicephala macrorhynchus*

The short-finned pilot whale is not listed under the ESA. However, the stock found in the Sea Range has been identified as a **strategic stock** under the MMPA because the average human-caused mortality may not be sustainable (Barlow et al. 1997).

The range of the short-fined pilot whale in the eastern North Pacific extends from the tropics to the Gulf of Alaska. However, sightings north of Point Conception are uncommon (Forney 1994) and the majority of sightings have been south and east of the Sea Range (Figure 3.7-36). Prior to the 1982 to 1983 El Niño event, short-finned pilot whales were commonly seen off southern California, with an apparent resident population around Santa Catalina Island (Dohl et al. 1981). After the El Niño event, they virtually disappeared from this region and few sightings were made from 1984 to 1992 (Oliver and Jackson 1987; Forney 1994). The reason for the decrease in numbers is unknown (Heyning et al. 1994b), but the El Niño event apparently disrupted their distribution pattern and they have not returned as residents to waters off southern California (Forney 1994). However, in 1993, six sightings of short-finned pilot whales were made off California; two of these were south of Point Conception (Mangels and Gerrodette 1994; NMFS unpublished data *in* Barlow et al. 1997).

Prior to 1982, Dohl et al. (1981) estimated a resident population of about 400 animals with a seasonal increase to 2,000 animals in winter. Before 1982, most pilot whale sightings were south or east of the Sea Range (Figure 3.7-36). After 1982, no abundance estimates were available, although from 1983 to 1989 pilot whales were sighted in low numbers offshore and in shallow waters around Santa Catalina Island (Shane 1995). Barlow and Gerrodette (1996) recently calculated an abundance estimate of 1,000 (CV=0.37) for California waters, based on 1991 and 1993 ship-based surveys within 300 NM (556 kilometers) of the coast. No pilot whales were sighted "on effort" within the Sea Range during the NMFS surveys used to estimate the number of pilot whales (see Section 3.7.1.5). A few tens of pilot whales might be found in the Sea Range primarily during autumn and winter of most years, but given the variation in numbers seen in the past, none to most of the California population could be present in the Sea Range. These animals could be present either in territorial or non-territorial waters.

The mean size of 41 groups of pilot whales seen in the Point Mugu Sea Range was 22 individuals and the mean size of 57 groups seen east of the Sea Range in coastal and nearshore areas was 18 individuals. The largest group of short-finned pilot whales seen in the Sea Range was of 200 animals. Given the low overall numbers in the study area in recent years, average group size at present may be lower.

Pilot whales feed primarily on commercial-sized squid (Heyning et al. 1994; Shane 1995). Shane (1995) speculated that competitive exclusion or displacement by Risso's dolphins may prevent co-occurrence of both species when food resources are limited.

In summary, the California population of the short-finned pilot whale is considered a **strategic stock** under the MMPA (Barlow et al. 1997). Its distribution changed following the El Niño event of 1982 to 1983 and it has only recently started to return to its former range in California. It is found primarily south and east of the Sea Range. During most years, at most a few tens of animals might be found in the Sea Range, primarily during autumn and winter. However, if oceanographic conditions are suitable, large numbers and a large fraction of the California population might be found in the Sea Range. In former years, short-finned pilot whales occurred in groups averaging about 20 animals, and they fed primarily on squid.

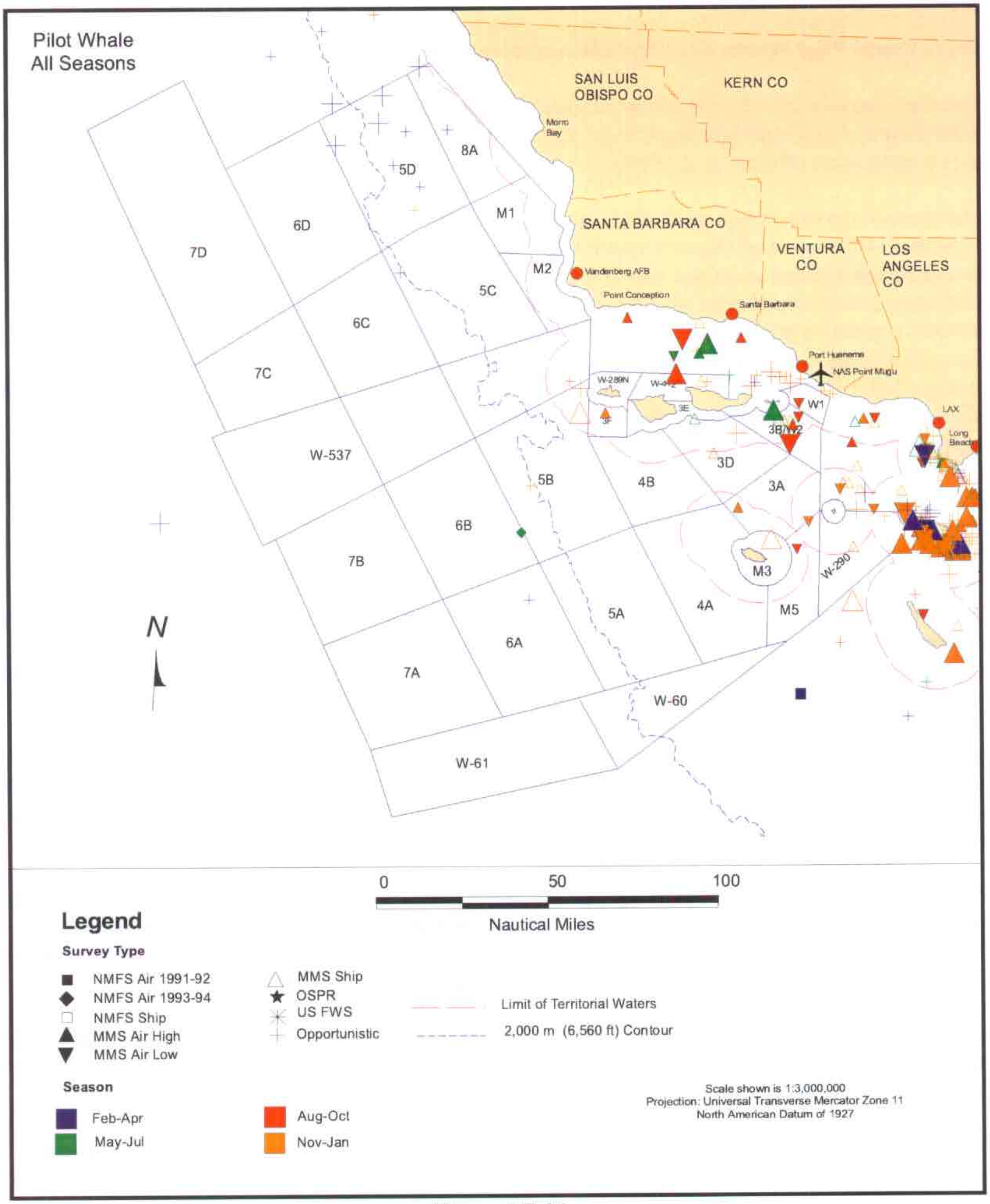


Figure 3.7-36

Sightings of pilot whales during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-20 vs. 21 or more animals, respectively. Note that almost all of the mapped sightings in the Southern California Bight were during BLM/MMS surveys in 1975-1978.

Cuvier's Beaked Whale, *Ziphius cavirostris*

Cuvier's beaked whale is not listed under the ESA, and the stock that inhabits the Sea Range is not considered to be a strategic stock under the MMPA. Trends in population size are unknown due to a paucity of data on both current and historic abundance.

Cuvier's beaked whales are distributed widely throughout deep waters of all oceans (Heyning 1989). Their distribution and abundance in and near the Point Mugu Sea Range are not well known because beaked whales are difficult to identify and many of the beaked whales that have been sighted have not been identified to species. Based on those that were identified, Cuvier's beaked whale appears to be the most abundant beaked whale in the area, constituting almost 80 percent of the identified beaked whale sightings (see Barlow and Gerrodette 1996). Figure 3.7-37 shows all beaked whale sightings within and near the Sea Range during the studies summarized. Cuvier's beaked whales are probably found throughout offshore waters of the Sea Range. There are no clear seasonal trends in distribution or abundance within the Sea Range except that this species has not been sighted in nearshore or coastal waters.

The best estimate of the number of Cuvier's beaked whales inhabiting waters off California comes from NMFS' ship-based surveys during the summer and autumn of 1991 and 1993. After allowance for unidentified beaked whales, whales at the surface but missed by observers, and the diving behavior of the whales, Barlow and Gerrodette (1996) estimated that 9,160 (CV=0.52) Cuvier's beaked whales were present. Based on the estimation procedure described in Section 3.7.1.5, 2,044 of these whales might be in the Point Mugu Sea Range throughout the year (Table 3.7-5). This estimate is very approximate because it is based on a small number of sightings and a large correction factor to account for a low probability of detection. Cuvier's beaked whales appear to dive to avoid ships (such as the census vessel), so the estimates are probably negatively biased despite the attempt to account for their low detectability.

The mean size of 27 groups identified as Cuvier's beaked whales within the Sea Range was 2.3 individuals. The largest group seen was of 11 whales.

The diet of the Cuvier's beaked whale is poorly known, but the few stomachs examined have contained squid and fish. The organisms eaten were open ocean, mesopelagic, or deep-water benthic organisms (Heyning 1989). This diet confirms that Cuvier's beaked whales are primarily inhabitants of deep offshore waters and suggests that they may dive to the bottom in water greater than 3,300 feet (1,000 meters) deep to feed.

In summary, Cuvier's beaked whale does not have a special status. It (and other beaked whales) is distributed throughout offshore waters of the Sea Range throughout the year. About 2,044 Cuvier's beaked whales may occur on the Sea Range. This species is found in small groups averaging 2.3 individuals and feeds on squid and fish found in deep water in offshore areas.

Sperm Whale, *Physeter macrocephalus*

Sperm whales are federally listed as **endangered** under the ESA and are considered **depleted** under the MMPA. Also, the stock that occurs in the Sea Range is considered to be a **strategic stock** (Barlow et al. 1997). The available data suggest that sperm whale abundance has been relatively stable in California waters since 1979/80 (Barlow 1994), but there is uncertainty both in the population size and the annual mortality rates.

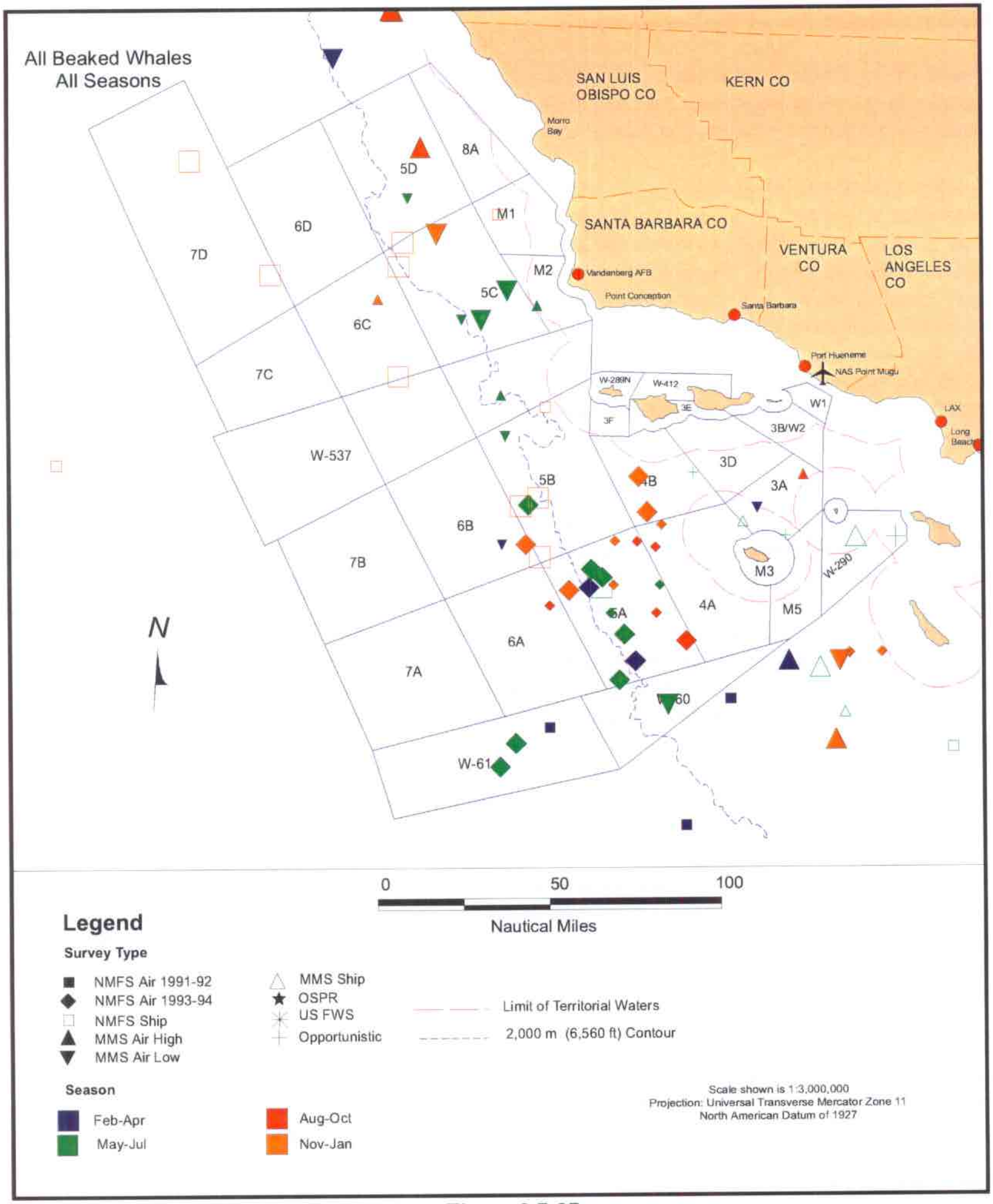


Figure 3.7-37

Sightings of all beaked whales during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively. Beaked whales are especially difficult to survey because they are below the surface most of the time.

Sperm whales are widely distributed in all oceans as far north and south as the edges of the polar pack ice; however, they are most abundant in tropical and temperate waters where the water temperature is higher than 59° F (15° C) (Rice 1989). Sperm whales show a strong preference for deep waters, and are usually found seaward of the continental slope.

Bonnell and Dailey (1993) reported that the sperm whale was rare over the continental shelf of the SCB, but that it was abundant directly offshore of the SCB. Only one of the 71 sperm whale sightings during the 1991 and 1993 SWFSC ship-based studies was within the Sea Range, confirming that sperm whales are more abundant farther offshore and farther south than they are in the SCB and Sea Range.

Notwithstanding this, other studies have shown that sperm whales occur in small to moderate numbers in all offshore portions of the Sea Range (Figure 3.7-38). Dohl et al. (1981) reported one sighting within the SCB during their 1975 to 1978 surveys. Their sighting (6 animals) was in water approximately 9,600 feet (2,930 meters) deep during October 1976. Dohl et al. (1983) recorded 6 sightings of sperm whales in offshore parts of the Sea Range north of Point Conception (triangles in Figure 3.7-38). Twelve sightings were made west of San Nicolas Island during SWFSC OSTR surveys (Table 3.7-6 and Figure 3.7-38; Carretta et al. 1994). Overall, there were 21 sightings of 118 sperm whales within the Sea Range during the studies summarized. None of these sightings were in nearshore waters or inshore of the islands.

In addition to the sightings shown in Figure 3.7-38, Leatherwood et al. (1987) reported a total of 11 sperm whale sightings over continental shelf waters of the northern SCB from 1965 to 1985. These sightings were presumably all within the Point Mugu Sea Range, as it includes all of the northern part of the SCB. Seven of those sightings were from waters immediately adjacent to the Channel Islands; the most recent sighting (October 1985) was just inshore of Anacapa Island (Leatherwood et al. 1987).

There is some doubt about the relative abundance of sperm whales off southern California during different seasons. Rice (1974) reports that sperm whales reach peak abundance in April through mid-June but Dohl et al. (1983) reported that, in central California, peak abundance occurred in autumn and winter during two of three years of study (Figure 3.7-39). Historically, whalers operating off southern California and northern Mexico commonly took sperm whales from November to April (Leatherwood et al. 1987). The majority of the sightings in Figure 3.7-38 were during winter (February to April); however, there was very little survey effort in offshore waters during autumn. It appears that, in most years, peak numbers of sperm whales occur in the Sea Range during autumn and winter, although they may be seen at any time of year.

Sperm whale abundance in California waters is poorly known. It was estimated as 1,231 (CV=0.39) based on ship-based surveys during summer of 1991 and 1993 (Barlow and Gerrodette 1996). However, this probably understates the importance of the Sea Range to sperm whales because summer is believed to be a season of low abundance for sperm whales off California, and because some sperm whales may have remained below the surface as the ship passed. Aerial surveys during winter of 1991 and 1992 suggested that at least 892 sperm whales were present in California waters (Forney et al. 1995). However, this estimate did not allow for the high proportion of sperm whales that are submerged as an aircraft passes. The true number was probably 3 to 8 times the estimate of 892, and possibly even more (Forney 1994; Barlow et al. 1997). Most sightings during these aerial surveys were in Area 2 of Forney et al. (1995) (0.00392 sperm whales per square NM [0.0134 per square kilometer]) and none were in Area 1 (Figure 3.7-2; Table 3.7-4).

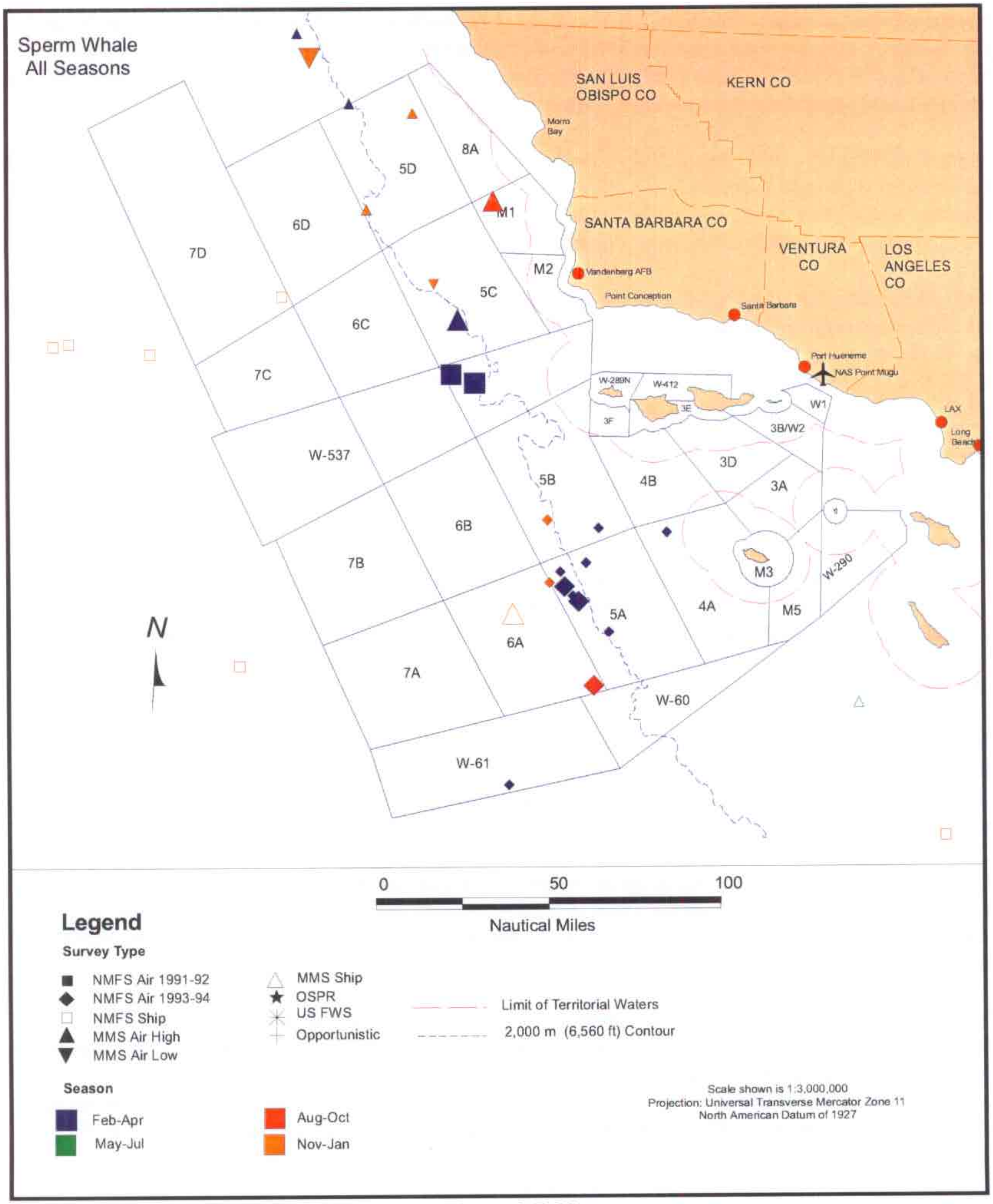


Figure 3.7-38

Sightings of sperm whales during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-5 vs. 6 or more animals, respectively. Sperm whales are especially difficult to survey because they are below the surface most of the time.

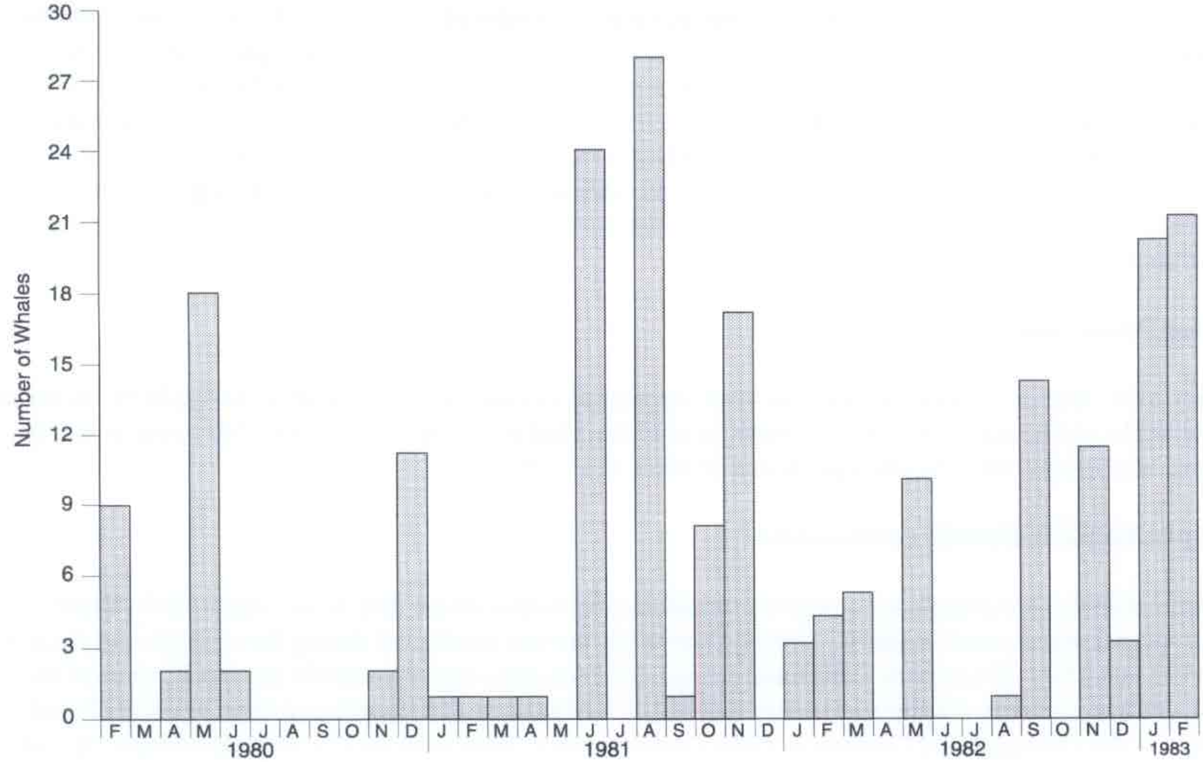


Figure 3.7-39
Comparison of total counts of sperm whales on aerial surveys of central and northern California by month, February 1980 – February 1983.
From Dohl et al. (1983).

Based on the estimation procedures described in Section 3.7.1.5, about 345 sperm whales are present in the Point Mugu Sea Range during summer, the season when the NMFS best estimate has been made. In autumn and winter, about 5,013 and 3,744 sperm whales, respectively, are estimated to be present in the Sea Range (Table 3.7-3). These estimates allow for the high proportion of the time that sperm whales spend below the surface. It is unknown how these autumn and winter estimates in the Sea Range compare to numbers in all California waters at that time of year.

Almost all sperm whales present in the Sea Range at all times of year occur in non-territorial waters. No sperm whales were sighted in territorial waters during any of the studies that are summarized in Figure 3.7-38. However, one sperm whale sighting near Anacapa Island during October 1985 (Leatherwood et al. 1987) indicates that this species may occasionally occur in territorial waters.

Sperm whales occur singly (usually older males) or in groups of up to 50 or more animals. The larger groups usually consist of bachelors or mixed groups of adult females and juveniles of both sexes (Dohl et al. 1983). The mean size of 21 groups sighted in the Sea Range and plotted in Figure 3.7-38 was 5.6 individuals; 9 of these groups were of single animals (primarily adult males) and the largest group encountered was of 21 individuals. Sperm whales feed mainly on medium to large cephalopods, which they apparently capture at depths ranging from several hundred to perhaps as great as 9,840 feet (3,000 meters) (Rice 1989). Up to 24 species of cephalopods were identified in the stomachs of sperm whales (Fiscus et al. 1989).

In summary, the sperm whale is listed as **endangered** and **depleted**, and the stock that occurs in the Sea Range is considered to be a **strategic stock** (Barlow et al. 1997). It is found throughout deep offshore waters warmer than 59° F (15° C) and is present throughout offshore waters of the Sea Range in all seasons except possibly spring. The sperm whale is probably present in largest numbers during autumn and winter when about 3,744 to 5,013 may be present in the Sea Range. Almost all sperm whales are expected to be found in non-territorial waters. This species is generally found in small groups (mean = 5.6 individuals). Sperm whales dive to great depths (down to 9,840 feet [3,000 meters]) and feed on medium to large cephalopods.

Other Odontocetes

Many other species of odontocetes have been reported as occasional or rare visitors to the SCB. None of these additional species are listed as endangered or depleted and none of the stocks that occur in the Sea Range are considered to be strategic stocks (Barlow et al. 1997).

Striped Dolphin, *Stenella coeruleoalba*

Striped dolphins are abundant in eastern tropical Pacific waters where they form large mixed schools with spinner and spotted dolphins. During ship-based surveys conducted during the summer and autumn of 1991 and 1993 off southern California, striped dolphins were seen commonly in mixed groups with short-beaked common dolphins in waters 100 to 300 NM (185 to 556 kilometers) from shore (Hill and Barlow 1992; Mangels and Gerrodette 1994; Barlow 1995). Only three of 121 ship-based sightings were within the Sea Range; other sightings were farther offshore (Hill and Barlow 1992). No striped dolphins were identified during aerial surveys conducted within 100 to 150 NM (185 to 278 kilometers) of the coast during winter and spring of 1991 and 1992 (Forney et al. 1995). The best estimate of the size of the striped dolphin population in California waters is 24,910 (CV=0.31, Barlow et al. 1997). Based on the procedures outlined in Section 3.7.1.5, about 7,887 striped dolphins are found in the Sea Range during summer. Because the striped dolphin is a pelagic species and there has not been adequate survey coverage in offshore waters during seasons other than summer, its abundance in the outer Sea Range is unknown during autumn to spring. All of the estimated 7,887 striped dolphins occurring in the Sea Range during summer are found in non-territorial waters.

Spinner Dolphin, *Stenella longirostris*

No spinner dolphins were identified in or near the study area during the recent studies from which sightings were mapped for this analysis, although they are common in nearshore areas off Central America. Also, no spinner dolphins were identified anywhere in California waters during SWFSC aerial or ship-based surveys conducted within 100 to 150 NM (185 to 278 kilometers) of the coast of California during 1991 and 1993 (Forney et al. 1995; Barlow and Gerrodette 1996). Thus no, or at most a few, spinner dolphins are expected to be present in the Sea Range. Because of their low California population size, all of the California population of spinner dolphins could be present in the Sea Range at one time. If they are present, they are likely to be in territorial waters.

Spotted Dolphin, *Stenella attenuata*

Spotted dolphins are typically found in tropical and temperate pelagic waters. No sightings of spotted dolphins have been made at sea in California waters, but a stranding has been reported at Aptos Creek, Santa Cruz County – approximately 25 NM (46 kilometers) north and east of the Sea Range (Worthy et

al. 1993). No, or at most a few, spotted dolphins are likely to occur in the Sea Range, but any animals that are present would represent a significant proportion (possibly all) of the California population.

Rough-toothed Dolphin, *Steno bredanensis*

Rough-toothed dolphins are typically found in tropical and warm temperate waters (Perrin and Walker 1975 *in* Bonnell and Dailey 1993). This species has not been positively identified alive in coastal temperate waters. The closest sighting during recent surveys was approximately 500 NM (926 kilometers) south of the Sea Range during ship-based surveys (Mangels and Gerrodette 1994). A few specimens have been collected from central and northern California, but these are believed to be extra-limital strays (Leatherwood et al. 1987). None to a few rough-toothed dolphins might be present in the Sea Range during summer. Any animals that are present would represent a significant fraction (possibly all) of the California population. They are most likely to be found in territorial waters.

Killer Whale, *Orcinus orca*

Killer whales are sighted occasionally in California waters, but no resident populations have been identified (Forney et al. 1995). During 1974 to 1984, 35 confirmed sightings were reported in the SCB, i.e., within the southern part of the Sea Range and a large area south of the Sea Range (Leatherwood et al. 1987). The few animals reported during the 1975 to 1978 surveys in the SCB were sighted during summer and winter (Dohl et al. 1981). Only two killer whales were sighted during aerial surveys in the winter and spring of 1991 and 1992 (Forney et al. 1995) and no killer whales were sighted within the Sea Range during ship-based surveys during the summer and autumn of 1991 and 1993 (Barlow 1995; Barlow and Gerrodette 1996). There were a total of 21 widely-scattered killer whale sightings in the Sea Range during all studies summarized in Figure 3.7-40.

Forney et al. (1995) estimated that 747 (CV=0.71) killer whales occur in waters off California. Based on the procedures described in Section 3.7.1.5, approximately 361 killer whales are present in the Sea Range throughout the year. Approximately 12 percent (43) of them are in territorial waters and 88 percent (318) are in non-territorial waters (Table 3.7-5).

False Killer Whale, *Pseudorca crassidens*

False killer whales occur predominantly in tropical to subtropical pelagic waters (Leatherwood et al. 1987; Bonnell and Dailey 1993). In the eastern North Pacific this species has rarely been reported north of Baja California (Leatherwood et al. 1982, 1987; Mangels and Gerrodette 1994). It is a sporadic visitor in California waters and records of strandings and sightings along the California coast are rare (Forney et al. 1994). None to a few false killer whales might be present in the Sea Range during summer. Any animals that are present would represent a significant fraction (possibly all) of the California population. They are most likely to be found in non-territorial waters.

Baird's Beaked Whale, *Berardius bairdii*

In addition to Cuvier's beaked whale (discussed earlier), several other beaked whale species occur in small numbers in southern California. Most beaked whales forage offshore in relatively deep waters (Leatherwood et al. 1987) and are unlikely to be encountered in significant numbers in the Sea Range.

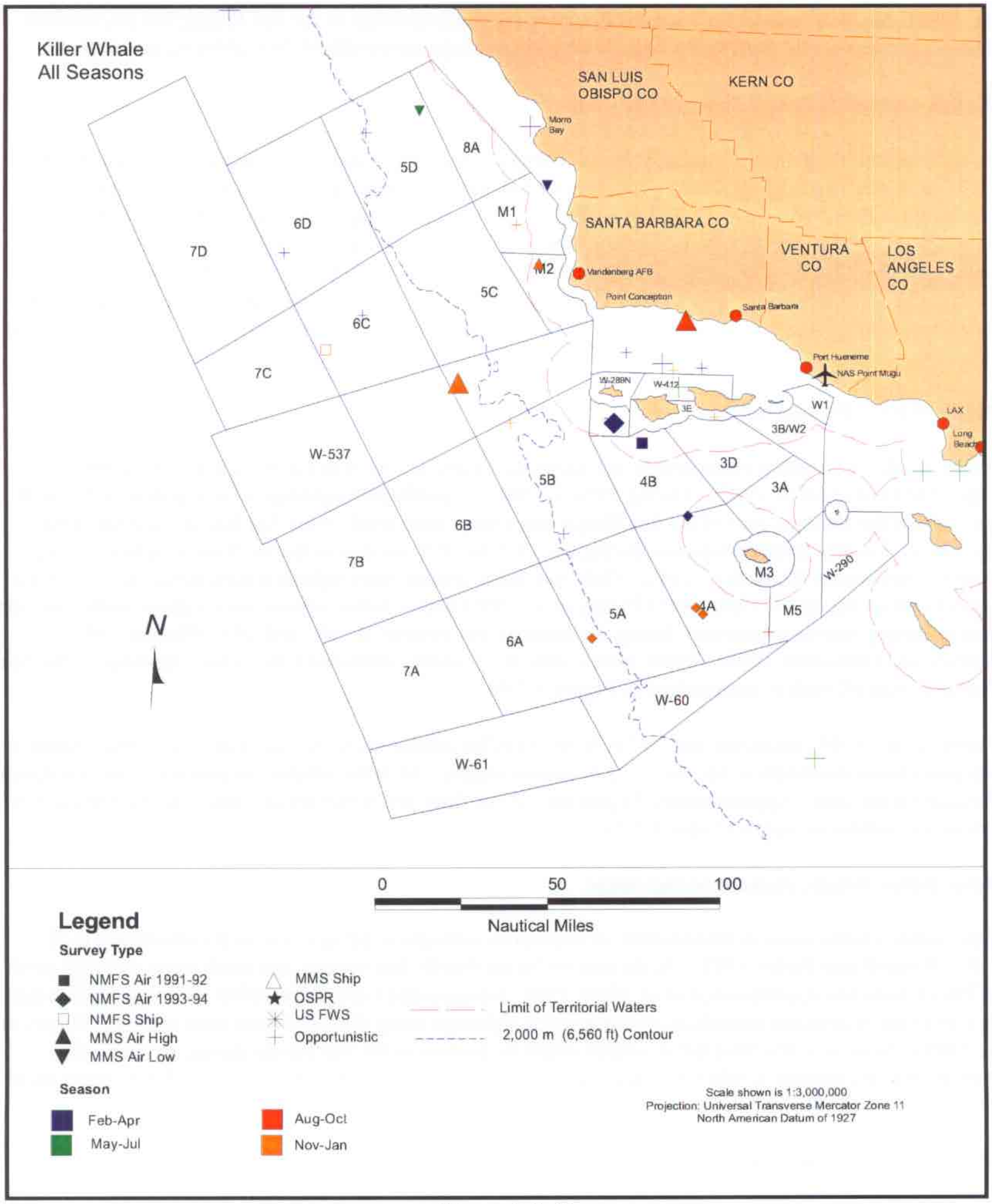


Figure 3.7-40

Sightings of killer whales during the 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-3 vs. 4 or more animals, respectively.

Baird's beaked whales are infrequently encountered along the continental slope and throughout deep waters of the eastern North Pacific (Forney et al. 1994; Barlow et al. 1997). Little is known about their seasonal movements or distribution, but it is suspected that they move into continental slope waters during the late spring through early autumn period and move farther offshore during other periods (Barlow et al. 1997). A total of 13 sightings (42 individuals) were made within the Sea Range during the studies that are summarized here. Dohl et al. (1981) rarely sighted this species during their surveys. None were sighted during aerial surveys reported by Forney et al. (1995). Only one group of 9 animals was sighted in the Sea Range during ship-based surveys conducted during the summer and autumn of 1991 and 1993 (Hill and Barlow 1992; Mangels and Gerrodette 1994). The best estimate of the number of Baird's beaked whales off California is 380 (CV=0.52) (Barlow and Gerrodette 1996). Based on the procedures described in Section 3.7.1.5, about 148 Baird's beaked whales are present in the Sea Range with more than 148 probably being present from late spring to early autumn and fewer than 148 present during the rest of the year. All Baird's beaked whales are expected to be found in non-territorial waters.

Mesoplodont Beaked Whales, *Mesoplodon spp.*

Mesoplodont beaked whales, including Hubbs', Hector's, gingko-toothed, Blainville's, and Stejneger's beaked whales as a group, are distributed throughout deep waters and along the continental slopes of the eastern North Pacific. These five species are known to occur near or in the Point Mugu Sea Range. All beaked whales are difficult to identify so most beaked whale sightings are not identified to the species level. None of the five species is listed as endangered under the ESA or depleted or a strategic stock under the MMPA. Until recently the California/ Oregon/Washington "population" of this species group has collectively been considered to be a **strategic stock** (Barlow et al. 1997). However, due to new information on population size, its status was recently changed to "**non-strategic**" (NMFS 1998; Barlow et al. 1998).

The available data about occurrence of particular mesoplodont species in and near the Sea Range has come mostly from stranding records. Along the coastline east of the Sea Range there is one record of a stranded Blainville's beaked whale near Ventura on 4 June 1984. There are two records of Hubbs' beaked whales in Santa Barbara County (11 June 1984 and 26 April 1992). A third stranding of a Hubbs' beaked whale occurred along the coast south of the Sea Range in Orange County on 3 June 1986. The paucity of sightings and strandings precludes any determination of spatial or seasonal patterns in mesoplodont beaked whale distribution or abundance.

Barlow and Gerrodette (1996) estimated that 2,106 (CV=0.79) mesoplodont beaked whales were present in offshore waters within 300 NM (556 kilometers) of the California coast. This estimate accounts for whales at the surface but missed by observers, the diving behavior of the whales, and the large number of unidentified beaked whales. Even with all of these corrections, the estimate is still probably low given that beaked whales are known to avoid ships (such as the census vessel) and are extremely difficult to detect and identify. Based on the procedures described in Section 3.7.1.5, an estimated 573 mesoplodont beaked whales are present in the Sea Range throughout the year, primarily in non-territorial waters.

Pygmy Sperm Whale, *Kogia breviceps*

Pygmy sperm whale strandings are infrequently reported in southern California. One of three reported strandings was at Point Mugu on 27 November 1985; a second was in northern Ventura County on 2 November 1983; and the third was along the coast south of the Sea Range in San Diego County. This species normally remains seaward of the continental shelf (Leatherwood et al. 1987; Caldwell and Caldwell 1989). Only one pygmy sperm whale was identified in the Sea Range during all of the recent

studies summarized here. It was sighted during autumn west of San Nicolas Island during NMFS/SWFSC surveys in 1993 to 1994 (Carretta et al. 1995). The best estimate of the California population size for pygmy sperm whales is 3,145 (CV=0.45) (Barlow and Sexton 1996). This estimate is based on ship-based surveys in 1991 and 1993 and is relatively unbiased because it includes corrections for diving behavior of pygmy sperm whales. Based on the above strandings and sighting, a few pygmy sperm whales are probably present in autumn in non-territorial waters in the Sea Range. Pygmy sperm whales are found singly or in groups of up to 6 individuals. Their diet consists of squid, benthic fish, and crabs, suggesting that they dive to considerable depths when feeding.

Dwarf Sperm Whale, *Kogia simus*

Dwarf sperm whales have not been seen during recent surveys within the Sea Range but have been seen both south and north of there. The dwarf sperm whale may inhabit waters over or near the edge of the continental shelf (Caldwell and Caldwell 1989) or the open sea. Mangels and Gerrodette obtained 31 sightings of dwarf sperm whales during their 1993 ship-based surveys: 28 sightings in the Gulf of California, one in nearshore waters west of Baja, and two in offshore waters between 20° and 25° north latitude. These data confirm that dwarf sperm whales often occur over the continental shelf, primarily south of the Sea Range. Thus, occasional dwarf sperm whales may be found in the Sea Range during summer and early autumn, when water temperatures are high, but they are unlikely to be present at other times of year. There is no good estimate of the California population size for the dwarf sperm whale, but Barlow and Gerrodette estimated that there are about 891 (CV=2.04) pygmy and/or dwarf sperm whales (*Kogia* sp.) in California waters. Some of the 891 are probably pygmy sperm whales but the proportion is unknown. This species is found singly or in small groups of up to about 6 animals. Their diet consists of squid, benthic fishes, and crabs.

3.7.2.2 Mysticetes (Baleen Whales)

All species of baleen whales that occur in the Sea Range have extensive ranges in the North Pacific, extending from high-latitude feeding grounds in the summer to subtropical calving grounds in the winter (Bonnell and Dailey 1993).

Blue, fin, and humpback whales are present in southern California offshore waters during the summer and autumn months (Heyning and Lewis 1990). Minke whales appear to be present year-round off the Channel Islands (Rice 1974; Leatherwood et al. 1987). In the autumn and winter, migrating gray whales are abundant both close to shore and in offshore migration corridors along and between the Channel Islands. Northern right, sei, and Bryde's whales are uncommon or rare in the area.

Northern Right Whale, *Eubalaena glacialis*

The northern right whale is federally listed as **endangered** under the ESA and the North Pacific stock is considered a **strategic stock** under the MMPA. The northern right whale may be the most endangered of the large whale species (Klinowska 1991).

The historic range included the entire North Pacific north of 35° north latitude and included occasional sightings as far south as 20° north latitude. Thus the Sea Range is along the southern boundary of the expected range. Recent sightings have been near shore in continental shelf waters, but there have been more opportunities for sightings in inshore than in offshore waters.

Scarff (1986) reported 23 reliable sightings of right whales in California waters, plus one additional stranding, for the years 1855 to 1982. Most of the sightings have been of single animals and most occurred in winter or early spring (March to May) and very close to shore (Scarff 1991). Only one of the records, a stranding on Santa Cruz Island in 1916, was within the Sea Range. One other sighting was WNW of Point Mugu on 17 April 1981 (Woodhouse and Strickley 1982); this sighting was east (inshore) of the Sea Range (Figure 3.7-41).

Since 1982, five additional sightings of right whales in California or Baja waters have been reported:

1. one whale off La Jolla on 5 February 1988 (Scarff 1991),
2. one whale 8.1 NM (15 kilometers) off Santa Catalina Island on 9 May 1990 (Figure 3.7-41),
3. one whale 38.0 NM (70.4 kilometers) southwest of San Clemente Island on 24 March 1992 (Carretta et al. 1994) (Figure 3.7-41),
4. one whale off Piedras Blancas on 3 May 1995 (Rowlett et al. 1994), and
5. one whale 8.1 NM (15 kilometers) off Cabo San Lucas on 19 February 1996 by D. Gendron (MARMAM posting).

Sightings 2 and 3 were outside of the Sea Range but near it (Figure 3.7-41). The other sightings were outside of the area mapped.

This stock was severely depleted by commercial whaling from an initial population of more than 11,000 (NMFS 1991) to at most 100 to 200 animals (Wada 1973; Braham and Rice 1984). There has not been a sighting of a northern right whale calf in the eastern North Pacific since 1900.

In summary, the northern right whale is listed as **endangered** under the ESA and the North Pacific stock is considered a **strategic stock**. In the northeastern Pacific, its numbers may have been reduced beyond the point of recovery. No live northern right whales have been seen in the Sea Range proper in the last 100 years. The scarcity of sightings and the very low population size indicate that it is very unlikely that right whales will be encountered in the Sea Range.

Gray Whale, *Eschrichtius robustus*

The eastern Pacific stock of the gray whale is not listed under the ESA, nor is it included as a strategic stock under the MMPA. It was recently removed from the list of threatened and endangered species due to increases in population size.

The vast majority of eastern North Pacific gray whales spend the winter months either in subtropical calving/breeding lagoons along mainland Mexico or along the west coast of Baja California. Most individuals spend the summer in feeding grounds in the Bering and southern Chukchi seas (Braham 1984; Leatherwood et al. 1987). During late winter and early spring they migrate north and during late autumn and early winter they migrate south along predominantly nearshore migration routes. However, the SCB is one part of the migration route where the whales tend to spread out somewhat, with some individuals following a more offshore route (Figures 3.7-42 to 3.7-45). Even so, almost all of the population passes either through the Sea Range or to the east of it during both the northward and the southward migration (Figure 3.7-42).

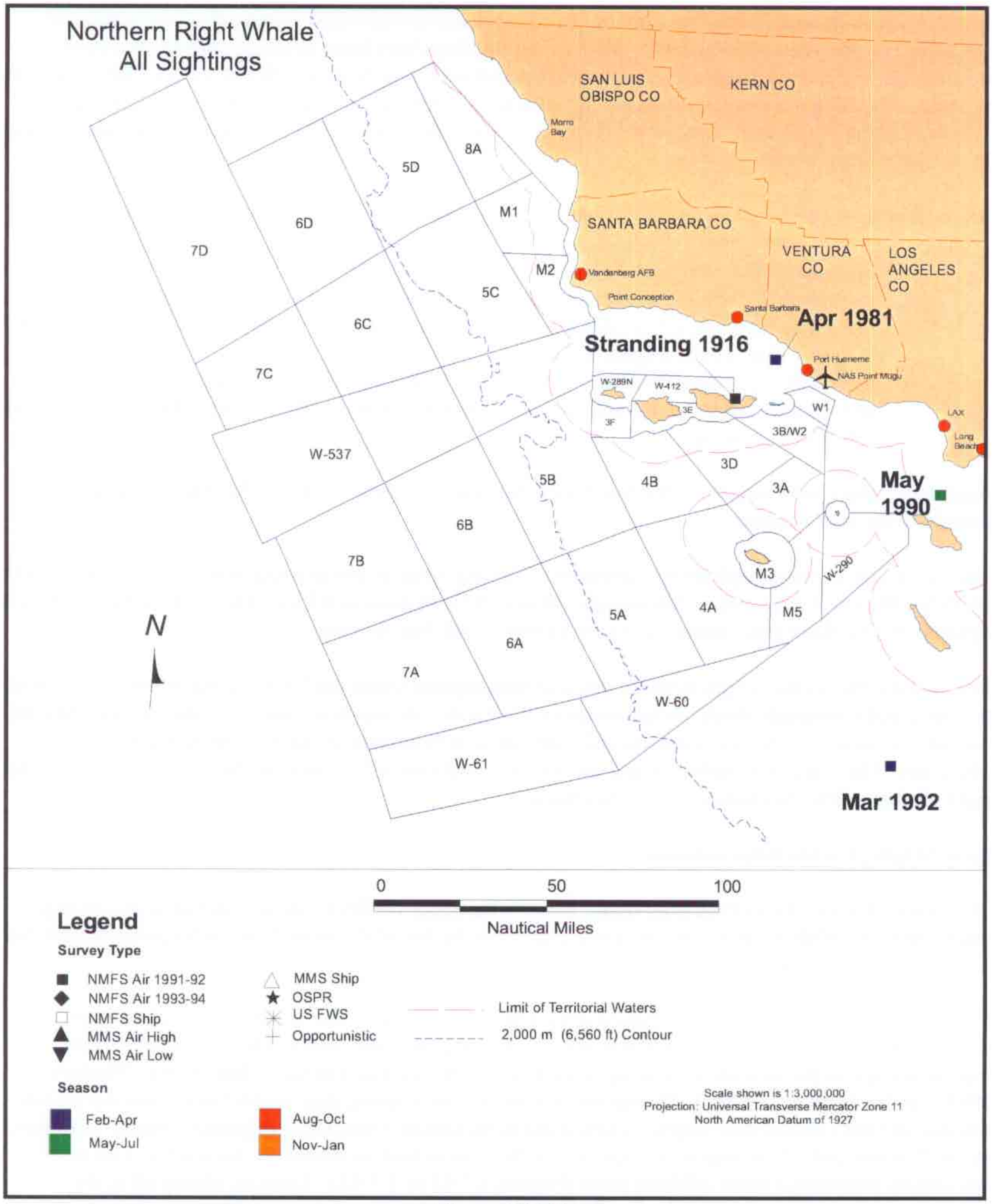


Figure 3.7-41
Sightings of northern right whales in and adjacent to the Point Mugu Sea Range. The 1916 sighting represents a stranding.

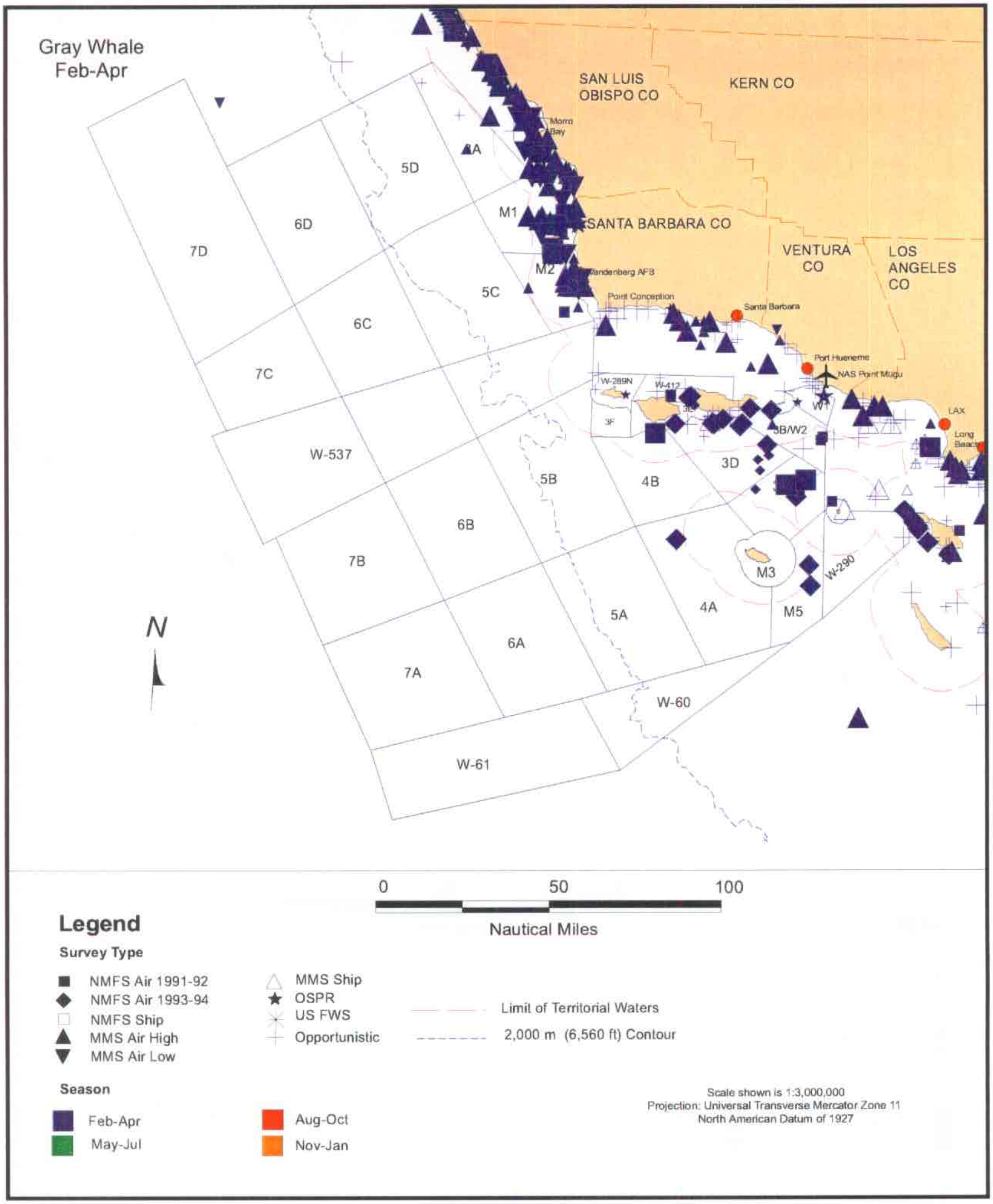


Figure 3.7-42
Sightings of gray whales during the February-April 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

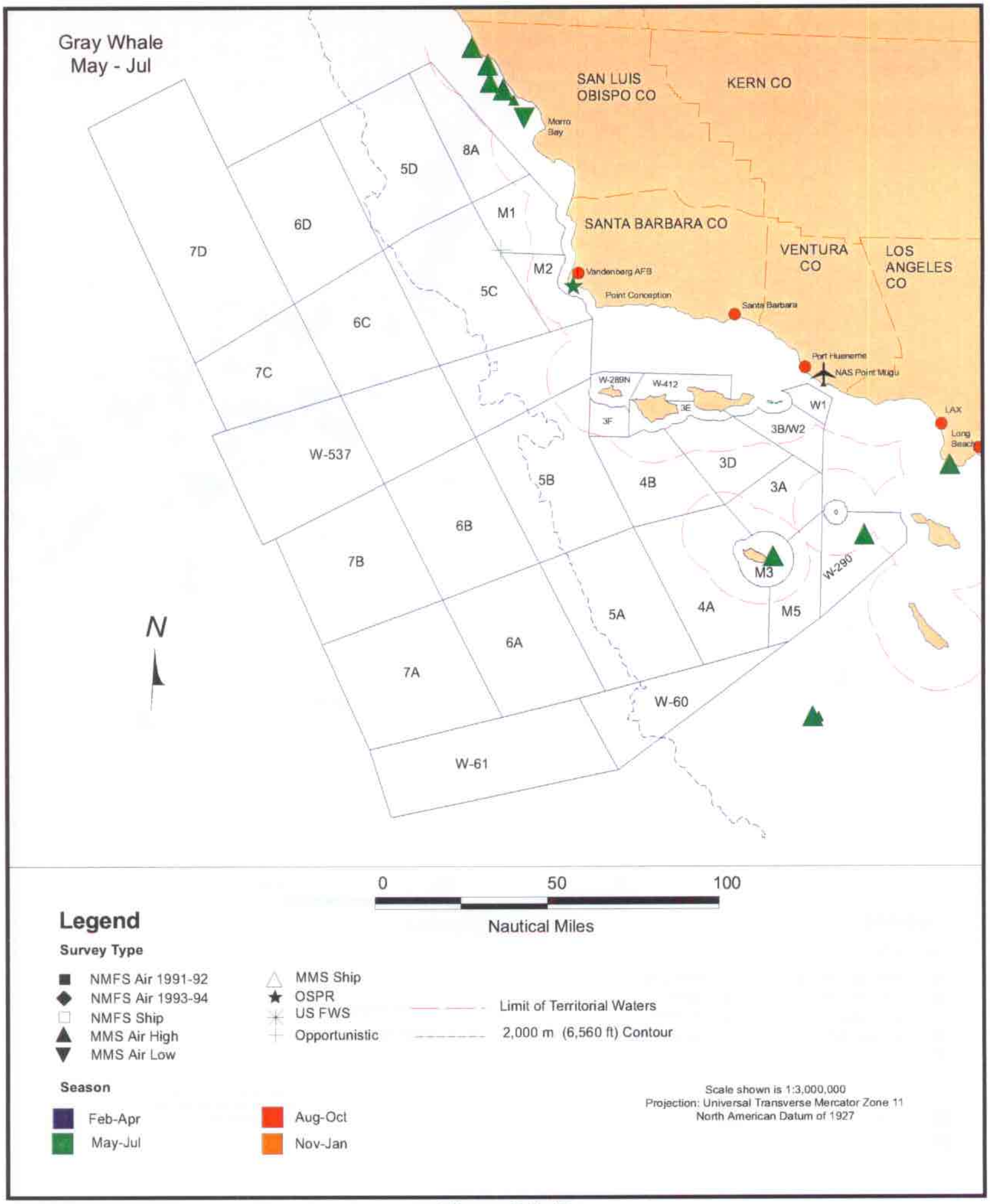


Figure 3.7-43
Sightings of gray whales during the May-July 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

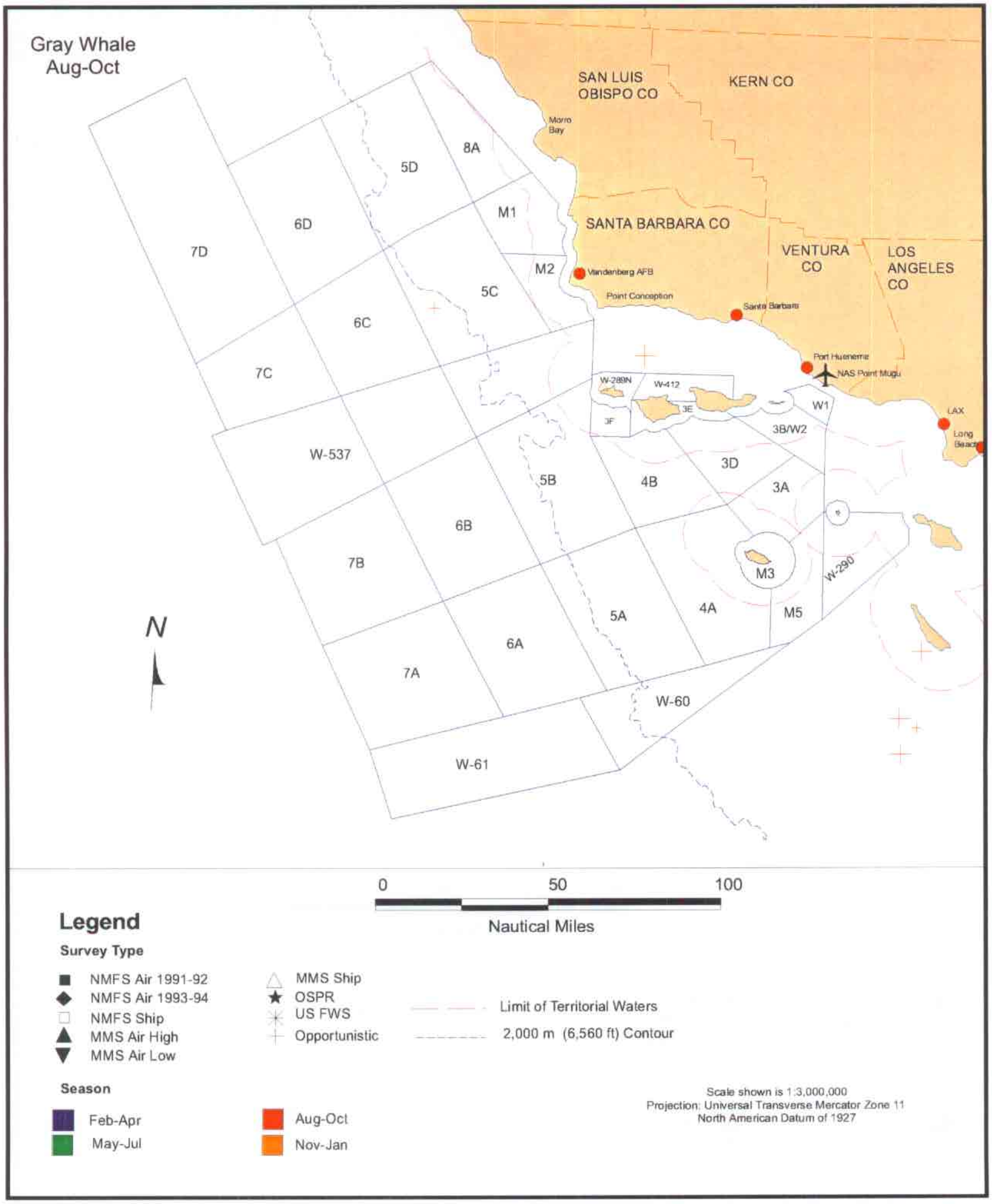


Figure 3.7-44

Sightings of gray whales during the August-October 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

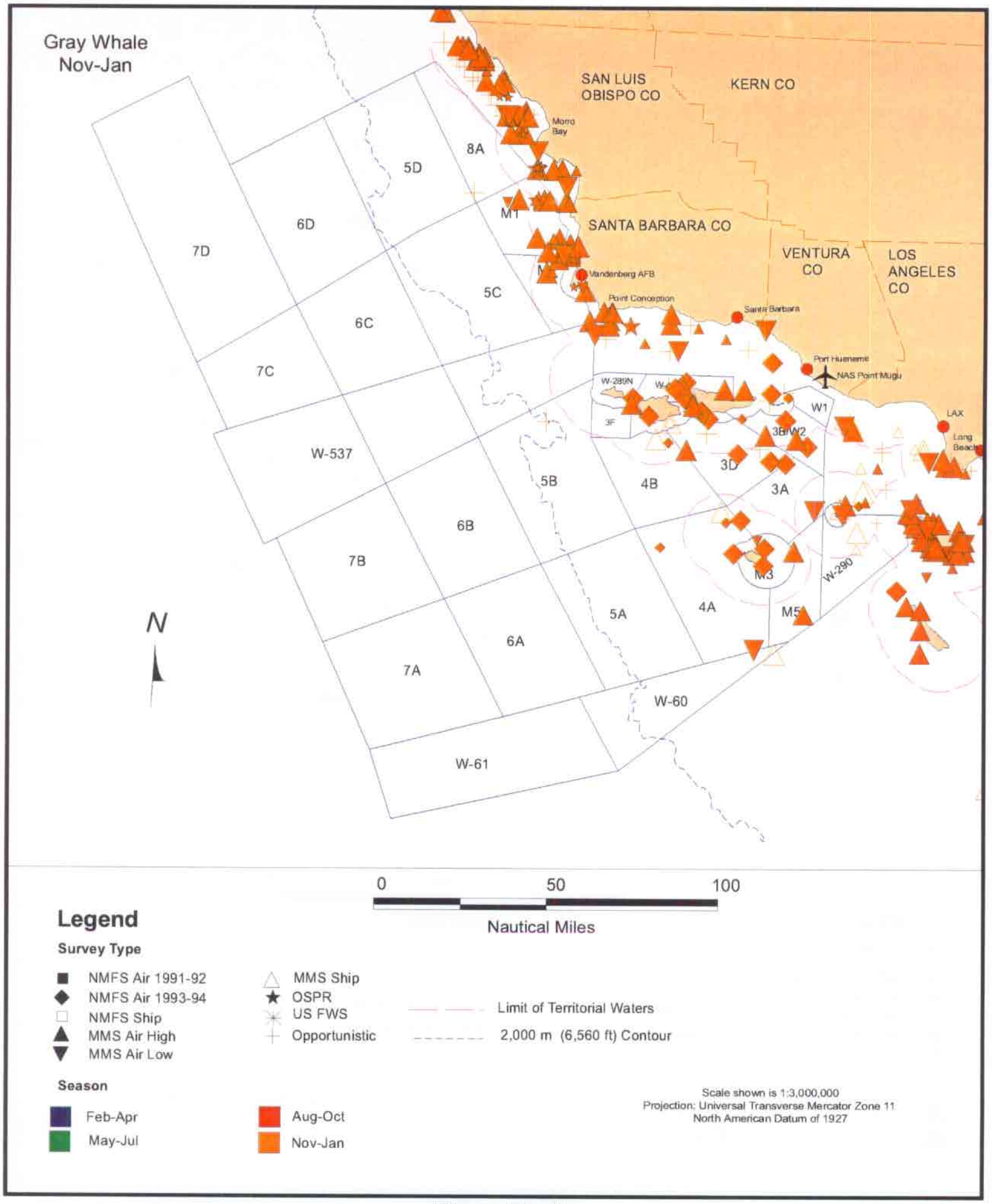


Figure 3.7-45

Sightings of gray whales during the November-January 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

North of Point Conception, the migration corridor is strongly concentrated along the shore, with the great majority of sightings being inshore of the Sea Range (Figure 3.7-42). Studies somewhat farther north along the central California coast show that 90 percent of the gray whales migrate within 1.73 NM (3.2 kilometers) of shore (Reilly et al. 1983). In the southern part of the Sea Range, where the migration route is not confined to coastal waters, gray whales are seen up to 108 NM (200 kilometers) offshore following three general routes (Figure 3.7-42 and 3.7-46). The nearshore pathway closely follows the mainland shore most of the way between Point Conception and Point Vincente (near Los Angeles). The inshore route includes the northern chain of the Channel Islands and then follows the eastern rim of the Santa Cruz Basin to Santa Barbara Island and Osborn Bank. From Santa Barbara Island, gray whales travel east to Santa Catalina Island, or southeast to San Clemente Island. The offshore route follows the undersea ridge from Santa Rosa Island, past San Nicolas Island, and over Tanner and Cortes banks in Mexican waters (Bonnell and Dailey 1993).

Aerial surveys during January 1986 and 1987 indicated that, at various times during southward migration, 613 to 756 gray whales were present in the Channel Islands National Marine Sanctuary, including waters within 6 NM (11.1 kilometers) of San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara islands (Jones and Swartz 1987 a,b). Of these, 29 to 36 were calves. Individual gray whales remained near the Channel Islands for periods of one to four days (Jones and Swartz 1987b). There was no difference between swimming speeds during day and night (Swartz and Jones 1987).

Southbound and northbound migrations into the Sea Range occur, for the most part, at predictable times. The southbound migration begins in the third week of December, peaks in January, and extends through February (Figure 3.7-47) (Gilmore 1960; Leatherwood 1974a). The northbound migration generally begins in mid-February, peaks in March and lasts at least through May. Gray whales are typically absent from August through November (Rice et al. 1981). However, there have been a few summer sightings (Figure 3.7-44; Patten and Samaras 1977).

Cows with calves are seen mainly from February through May during the northward migration (Leatherwood 1974a), but a very small number of calves have also been seen during the southward migration (Sheldon et al. 1996). Median sighting dates of calves during southbound migration have ranged from 10 to 24 January (Sheldon et al. 1996).

The eastern North Pacific stock of gray whales was believed to consist of about 23,109 (CV=0.074) individuals during 1993-1994 (Small and DeMaster 1995). The annual rate of population increase, based on shore counts of southward migrating whales, is 2.57 percent (SE=0.4) (Small and DeMaster 1995). All of the gray whales pass through or just east of the Sea Range twice a year, once on their southbound migration and again during their northbound migration. North of Point Conception the migration is strongly coastal and most gray whales pass east of the Sea Range. South of Point Conception there is no quantitative information on what fraction of the animals travel through the Sea Range vs. along the coast east of there, but Figures 3.7-42 and 3.7-45 suggest that the offshore route through the Sea Range may be the principal route. The number of gray whales present in or east of the Sea Range at any given time depends on the stage of the migration. Based on the procedure described in Section 3.7.1.5, about 1,747 gray whales are present at any given time in the Sea Range during the autumn southward migration; 86 percent (1,505) of them are found in territorial waters. During their northward migration in winter, about 2,345 are present and 73 percent (1,704) are found in territorial waters.

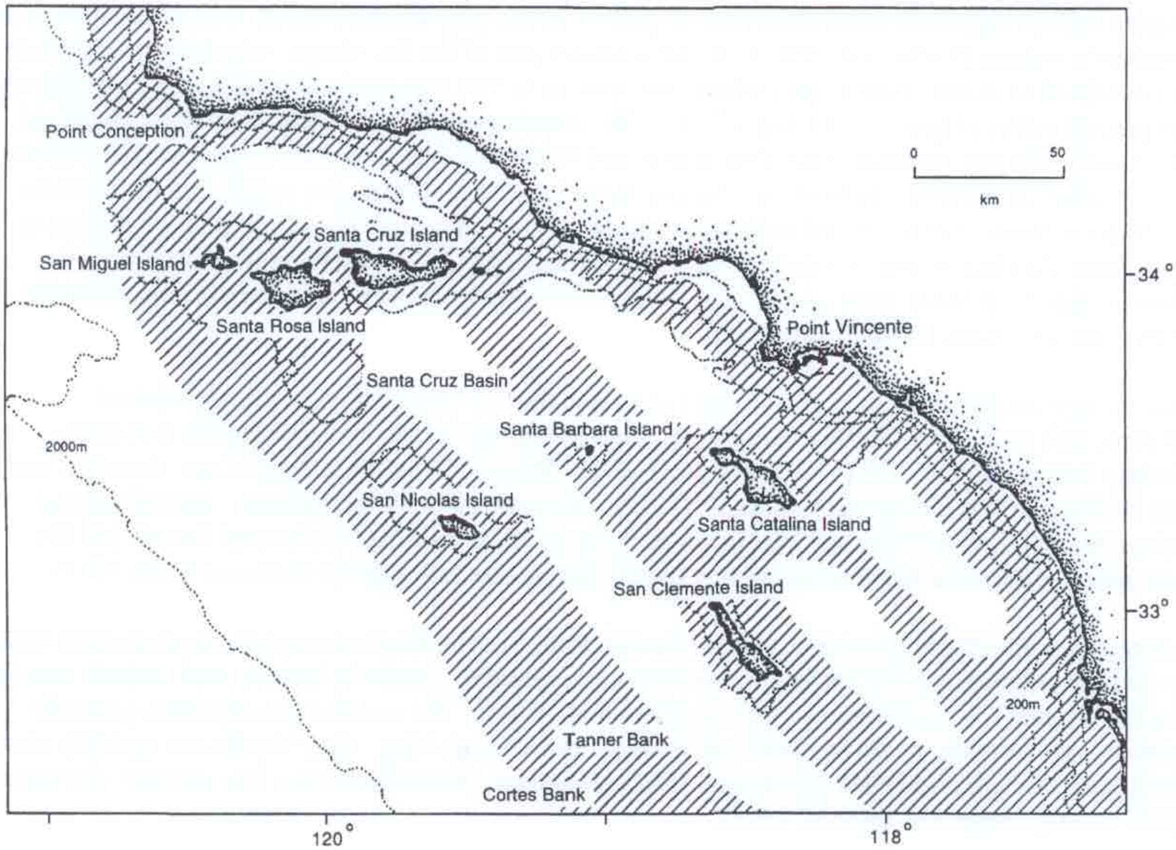


Figure 3.7-46
Migration pathways used by gray whales passing through the Southern California Bight, 1975-78. From Bonnell and Dailey (1993).

Migrating gray whales are commonly seen alone or in groups of two to three animals, although groups as large as 16 have been reported (Leatherwood and Reeves 1983). The mean size of 141 groups sighted within the Point Mugu Sea Range was 3.2 animals and the mean size of 428 groups seen east of the Sea Range was 2.6 animals. The largest group seen within the Sea Range was 27 animals. There is no apparent difference in pod sizes between day and night (Donahue et al. 1995).

Gray whales do not appear to spend much time feeding during their northward and southward migrations through the Sea Range. While in their northern feeding areas, gray whales feed primarily on benthic organisms. However, the few observations of juveniles and mothers feeding in and near the Sea Range have suggested that, in the Sea Range, gray whales may capture pelagic prey such as schooling fish. Gray whales are often associated with other marine mammals, including bottlenose dolphins, northern right-whale dolphins, common dolphins, Pacific white-sided dolphins, and Dall's porpoises (Leatherwood 1974b).

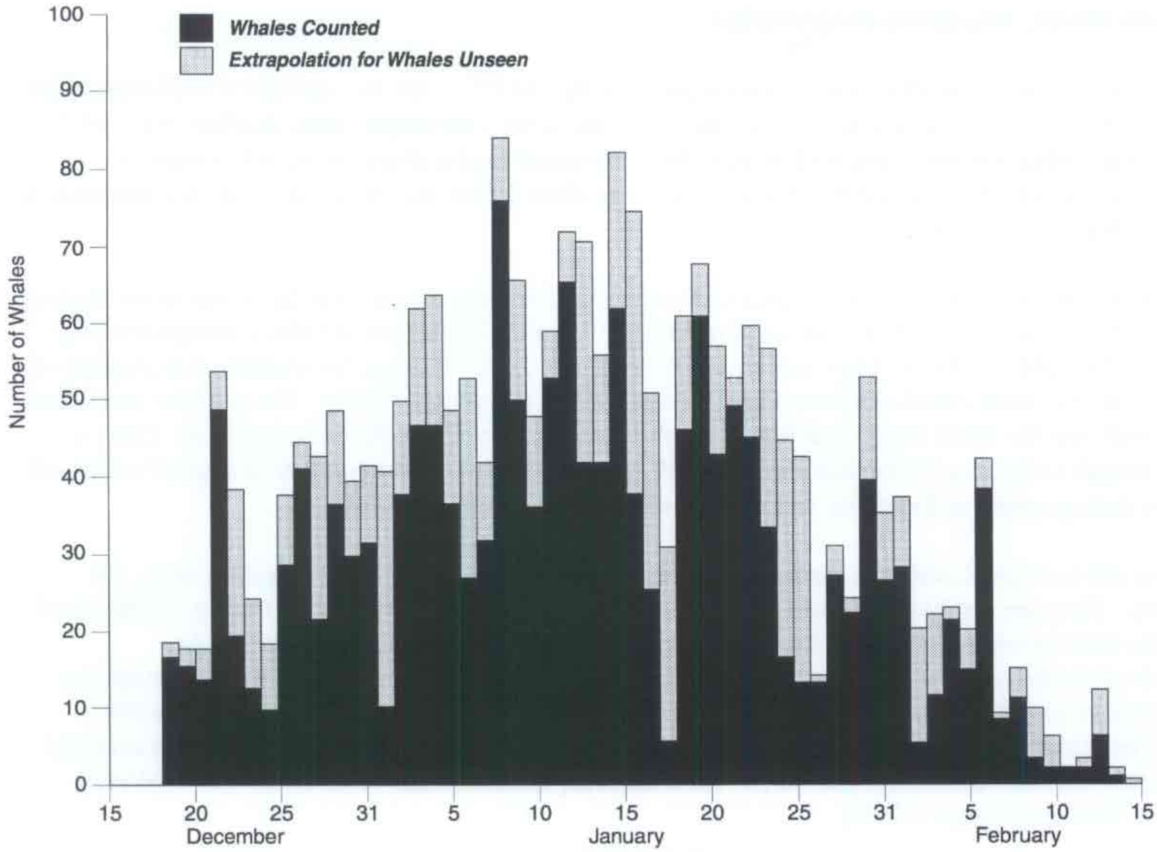


Figure 3.7-47
Daily counts and extrapolations of gray whales passing San Diego during the southbound migration, 1954-55.
From Gilmore (1960).

In summary, the gray whale no longer has a special status since its recent removal from the "endangered" list. During its autumn migration southward and its winter migration northward, most of the approximately 23,100 gray whales in the eastern North Pacific stock pass through or inshore of the Point Mugu Sea Range. The southbound migration begins in late December, peaks in early-to-mid January, and extends through February. The northbound migration begins in mid-February, peaks in March, and extends through May. North of Point Conception, the migration corridor is largely inshore of the Sea Range. In the SCB, gray whales follow three general routes through or near the Sea Range. (1) A nearshore route follows the coast and is primarily east of the Sea Range. (2) An inshore route goes from Point Conception to the Channel Islands, east to Santa Cruz Island, southeast to Santa Barbara Island, and east and southeast to Santa Catalina and San Clemente islands. (3) An offshore route goes from Point Conception to the western Channel Islands, southeast to San Nicolas Island, and southeast from there. Survey data suggest that about 86 percent of gray whales occur in territorial waters within the Sea Range during their southbound migration in autumn, and that 73 percent occur in territorial waters during their northbound migration in winter. Gray whales do not spend much time feeding in the Sea Range and typically pass through it in a few days or less. Northbound mothers and calves travel more slowly than other whales and tend to be seen later in the season than other northbound gray whales.

Humpback Whale, *Megaptera novaeangliae*

Humpback whales are federally listed as **endangered** under the ESA and are considered **depleted** under the MMPA; the stock that occurs in the Sea Range is considered a **strategic stock** (Barlow et al. 1997). There is some indication that humpback whales have increased in abundance in coastal waters of California between 1979/80 and 1993 (Barlow and Gerrodette 1996), but these trends are not statistically significant (Barlow et al. 1997).

Humpback whales occur worldwide, migrating from tropical breeding areas to polar or sub-polar feeding areas (Jefferson et al. 1993). Although the International Whaling Commission (IWC) recognizes only one stock of humpback whales (Donovan 1991), there is now good evidence for multiple populations of humpbacks in the North Pacific (Johnson and Wolman 1984; Baker et al. 1990). The putative stock that occurs in and near the Point Mugu Sea Range inhabits waters from Costa Rica (Steiger et al. 1991) to southern British Columbia (Calambokidis et al. 1993). This stock is most abundant in coastal waters off California during spring and summer and off Mexico during autumn and winter.

The waters off southern California are migration corridors, and to a lesser degree feeding areas, for humpbacks. They are rarely seen in and near the Sea Range during winter; only two winter sightings of humpbacks were recorded in the Sea Range during the studies summarized on Figure 3.7-48. Humpbacks are seen near the mainland coast and Channel Islands in small numbers during the spring (23 sightings in Sea Range), summer (27 sightings in Sea Range), and autumn (10 sightings in Sea Range). These sightings have occurred as humpbacks traveled between summer feeding areas centered in central and northern California (36° to 39° north latitude; Calambokidis et al. 1996) and wintering grounds off Mexico (Figure 3.7-48).

Evidence of feeding in the SCB during several months of the year indicates that not all humpback whales are simply passing through the area (Leatherwood et al. 1987). Humpback whales are sighted more frequently in the northern part of the Sea Range and nearby coastal areas than in the southern part of the Sea Range (Figure 3.7-48). This probably reflects, at least in part, the use of those areas by feeding whales. The Santa Barbara Channel also appears to be a humpback whale feeding area in some years (Schulman et al. 1984). In the early 1980s, sightings of 20 to 30 whales per year were recorded in the Santa Barbara Channel from May to September (Schulman et al. 1984). These sightings were additional to those during the studies summarized in Figure 3.7-48.

Humpback whales are sometimes seen in nearshore areas less than 3 NM (5.6 kilometers) from shore. Subsections 3.7.4.2 and 3.7.5.2 (later) include details concerning sightings near San Nicolas Island and the other Channel Islands, respectively.

The pre-exploitation stock in the North Pacific was estimated to be 15,000 humpback whales (Rice 1974). The North Pacific populations now probably total more than 3,000 animals (Barlow et al. 1997). The most precise and least biased estimate for the California-Washington "feeding" stock is 597 whales (CV=0.07), based on mark-recapture analyses of photographs taken in 1992 and 1993 (Calambokidis and Steiger 1994; Barlow et al. 1997). Most of these 597 animals pass through the Sea Range during their annual north-south migration. Based on the procedures described in Section 3.7.1.5, 220 humpback whales are estimated to be present in the Sea Range during the summer feeding period. During that period 46 percent (101) of the humpbacks in the Sea Range are found in territorial waters and 54 percent (119) are found in non-territorial waters (Table 3.7-5). No humpback whales are estimated to be present

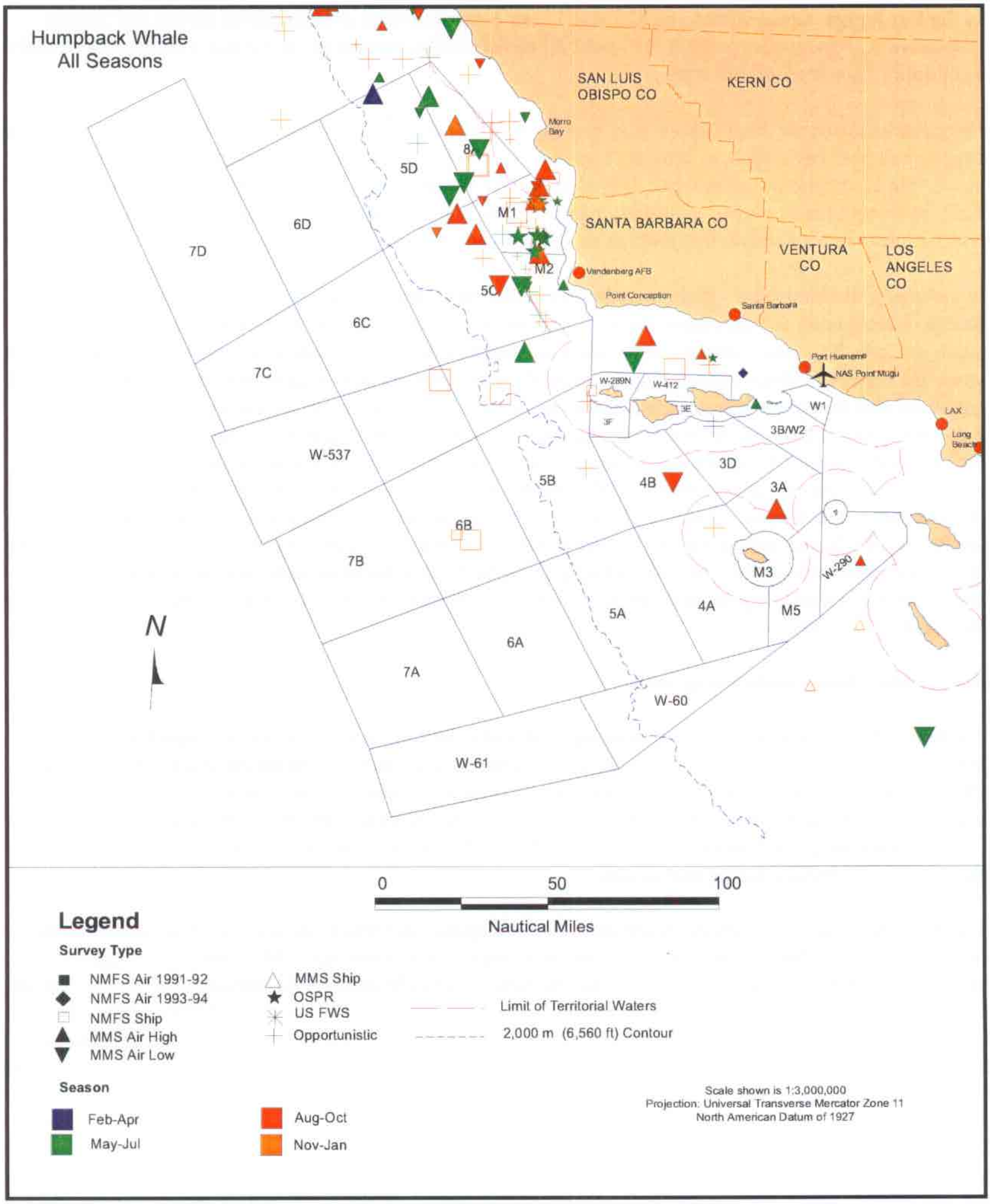


Figure 3.7-48

Sightings of humpback whales during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

in the Sea Range during winter and 125 and 13 are estimated to be present during spring and autumn, respectively. Ninety-four percent (117) and all of the whales present in spring and autumn, respectively, are found in non-territorial waters.

Humpback whales are found alone or in groups of two or three, but throughout their breeding and feeding ranges they may congregate in groups of up to 12 or 15 (Leatherwood and Reeves 1983). The average size of the 62 groups of humpbacks sighted in the Sea Range (see Figure 3.7-48) was 2.9 individuals. Krill make up a major part of their diet; pelagic crabs, cod, and small schooling fish such as anchovies and sardines are also consumed (Dohl et al. 1981; Leatherwood et al. 1987).

In summary, the humpback whale is **endangered** and **depleted** and the stock that occurs in the Sea Range is designated as a **strategic stock**. The population that occurs in the Sea Range winters as far south as Costa Rica and summers as far north as southern British Columbia, but most individuals of this stock are found off Mexico during winter and off central and northern California during summer. There are about 600 animals in this population and the stock size appears to be increasing slowly. Most of these whales pass through the Sea Range during their north-south migration to and from feeding areas farther north but only a fraction of the population is present in the Sea Range at one time. Feeding concentrations totaling approximately 220 humpback whales are found in the Sea Range during summer. Almost half of the feeding whales are found in territorial waters. Humpback whales are rarely found in the Sea Range during winter and only a fraction of the population is present in the Sea Range during the spring and autumn migration periods. During the spring and autumn periods most whales are found in non-territorial waters. Humpbacks are found singly or in small groups (average 2.9 individuals) and they feed primarily on krill.

Blue Whale, *Balaenoptera musculus*

The blue whale is federally listed as **endangered** under the ESA and is considered **depleted** under the MMPA. Animals found in the Sea Range are considered to be part of a **strategic stock** (Barlow et al. 1997). There is evidence that blue whales have increased in abundance in coastal waters of California between 1979/80 and 1991 ($p<0.05$, Barlow 1994). These increases have been too large to be accounted for by population growth alone (Barlow et al. 1997). Thus some, if not all, of the increase may be due to changes in distribution during that period.

The blue whale has a worldwide distribution in circumpolar and temperate waters. Blue whales in the North Pacific have been considered to comprise a single stock (Donovan 1991), but it is currently believed that more than one population inhabits these waters (Braham 1991; Barlow et al. 1997). Based on current and past distribution of blue whales in the North Pacific, Reeves et al. (1998) suggest that there may be at least five populations, with an unknown degree of mixing among them. The population that uses coastal waters of California is present there from June to November. This population is thought to inhabit waters off central America from December to May (Calambokidis 1995).

During autumn and winter, very few blue whales are present in waters off California (two and one sightings, respectively, during the surveys summarized in Figure 3.7-49). A few blue whales are seen in the Sea Range and nearby areas in early-to-mid spring (four sightings), but they are most common during the July to September period (43 sightings in July and 65 sightings in August and September during the surveys summarized in Figure 3.7-49; see also Teranishi et al. 1997). In some years blue whales are common in and adjacent to the Sea Range as late as mid-October (e.g., in 1995, Spikes and Clark 1996; Clark and Fristrup 1998; Clark et al. 1998). Waters west of San Nicolas Island are often used for feeding (Figure 3.7-49). Ship-based surveys of waters 0 to 300 NM (0 to 556 kilometers) from the California

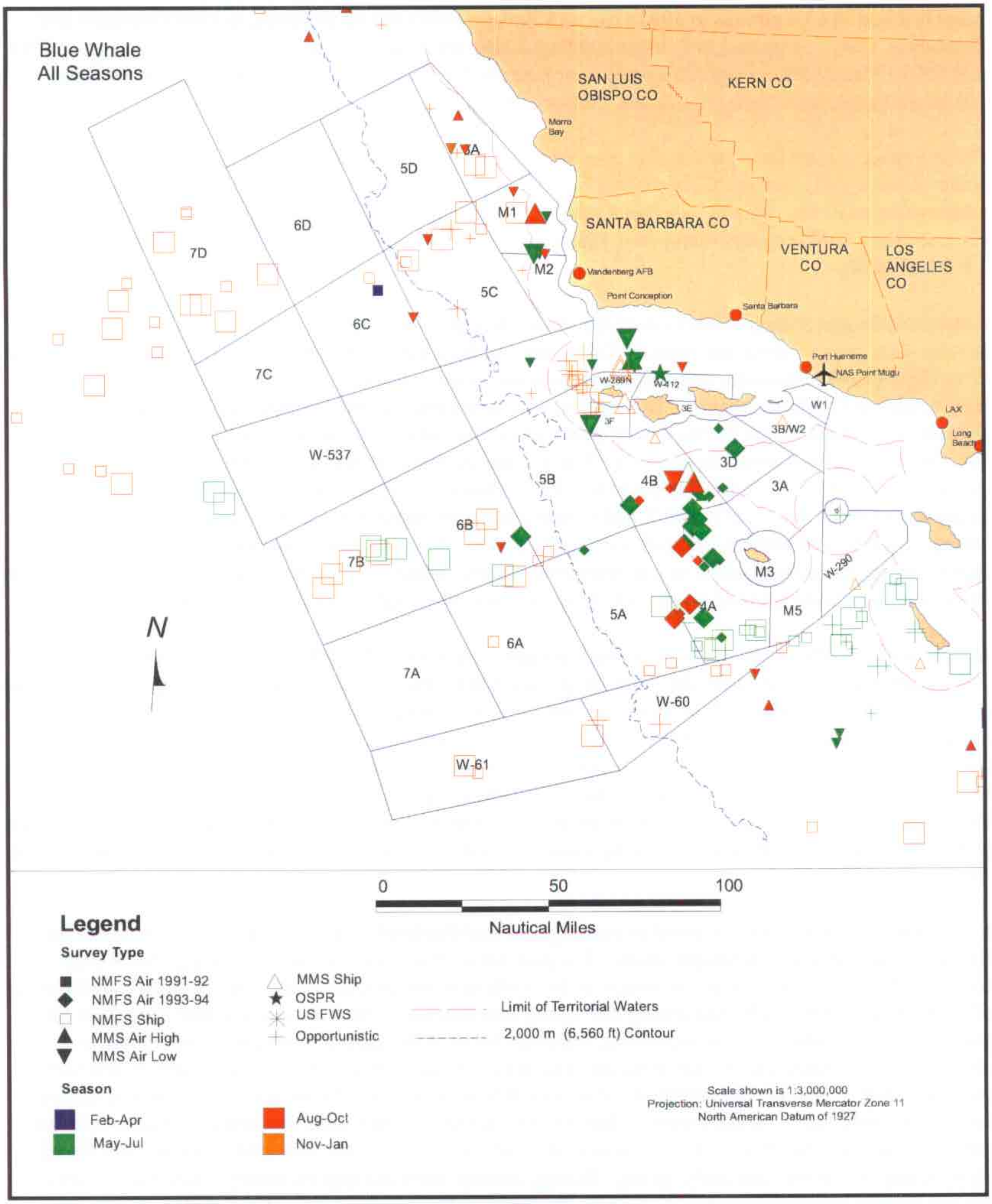


Figure 3.7-49

Sightings of blue whales during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

coast resulted in 63 sightings in 1991 (Hill and Barlow 1992) and 82 sightings in 1993 (Mangels and Gerrodette 1994), compared to a single sighting during aerial surveys in winter and early spring of 1991 and 1992. Many of these sightings were in or near the Sea Range (shown as open squares in Figure 3.7-49) as well as in areas farther north and farther offshore.

Photographic studies have proven that blue whales remain in waters off California throughout the summer, apparently to feed (Calambokidis 1995). In addition to the sightings shown in Figure 3.7-49, concentrations of blue whales have been seen in or adjacent to the Sea Range in some years. Calambokidis (1995) reported that over 100 blue whales were present in the Santa Barbara Channel in 1992 and 1994.

Calambokidis and Steiger (1994) estimated, from photographic evidence, that 2,017 (CV=0.38) blue whales were present along the coast of California and Baja during the 1986 to 1993 period. Barlow and Gerrodette (1996) estimated, from recent ship-based transect surveys, that there were 1,723 (CV=0.23) blue whales in California waters. The Barlow and Gerrodette (1996) estimate may be negatively biased because it did not account for the diving behavior of blue whales; however, this bias is expected to be low for blue whales during ship surveys. The average of these estimates, inversely weighted by their variances, is 1,785 (CV=0.24, Barlow et al. 1997). Based on the procedures described in Section 3.7.1.5, estimated totals of 266, 1,235, 1,612, and 0 blue whales are present in the Sea Range during winter, spring, summer, and autumn, respectively (Table 3.7-5). Almost all blue whales (92 to 100 percent, depending on the season) occur in non-territorial waters (Table 3.7-5). They are most likely to be found close to shore during summer when 135 (8 percent) are estimated to occur in territorial waters.

Blue whales usually occur singly or in small groups (Leatherwood and Reeves 1983). The mean size of 125 groups sighted in and near the Point Mugu Sea Range was 2.5 individuals, excluding one large group of 240 whales. Blue whales feed almost exclusively on euphausiids concentrated in the deep scattering layer and in daytime surface swarms (Schoenherr 1991; Calambokidis 1995), or on vertically migrating prey species that are near the surface at night (Lagerquist et al. 1995). Their diving behavior is variable. In one study, 75 percent of dives monitored with satellite tags were to depths of 52 feet (16 meters) or less (Lagerquist et al. 1995). In other circumstances, whales commonly dove to depths of 330 to 660 feet (100 to 200 meters), with dives averaging about 230 feet (70 meters) (D. Croll, personal communication 1998).

In summary, the blue whale is listed as **endangered** and **depleted** and the stock that occurs in the Sea Range is designated as a **strategic stock**. The population that occurs in the Point Mugu Sea Range winters off Central America and summers as far north as northern California. This species is common in offshore areas of the Sea Range during late spring and summer. There are about 1,800 animals in this population and it appears to be increasing, although some of the apparent increase is likely due to changes in distribution rather than population increase. Most of this population summers in and north of the Sea Range. Feeding concentrations of up to 100 blue whales are found near the Sea Range during summer in some years. Waters west of San Nicolas Island are often used for feeding. Blue whales are rarely found in the Sea Range during autumn and early winter and only very small numbers are found there during late winter and early spring. During summer there are approximately 1,600 blue whales in the Sea Range; only 135 (8 percent) of them are found in territorial waters. Blue whales usually are found singly or in small groups (average 2.5 individuals). They feed in deep offshore waters primarily on euphausiids, often near the surface (in the upper 52 feet of the water column) but sometimes to considerably deeper depths.

Fin Whale, *Balaenoptera physalus*

The fin whale is federally listed as **endangered** under the ESA and is considered **depleted** and a **strategic stock** under the MMPA (Barlow et al. 1997). There is evidence that fin whales have increased in abundance in coastal waters of California between 1979/80 and 1993 (Barlow 1994; Barlow and Gerrodette 1996). However, these increases are not statistically significant (Barlow et al. 1997).

Fin whales have a worldwide distribution with two distinct stocks being recognized in the North Pacific: the East China Sea stock, and "the rest of the North Pacific stock" (Donovan 1991). There is evidence for additional subpopulations in the North Pacific, but the ranges of these putative subpopulations and the extent of interchange among them are unknown. Presently, there are considered to be three stocks in the North Pacific for management purposes: an Alaska stock, a Hawaii stock, and a California/Oregon/ Washington stock (Barlow et al. 1997).

Fin whales are found on the continental slope and in offshore waters of California throughout the year, but in the Sea Range they are sighted most frequently during summer. There were 56 summer sightings during the studies summarized in Figure 3.7-50, as compared with 10, 22, and 9 sightings during winter, spring, and autumn, respectively. Dohl et al. (1981) reported that fin whales were sighted in low numbers year-round in the SCB, but that 87 percent of their sightings were recorded from March to October. Similarly, abundance estimates for waters off the California coast were twenty-fold higher in summer and autumn of 1991 and 1993 (approximately 933 animals) than in winter and spring of 1991 and 1992 (approximately 49 animals) (Table 3.7-4; Forney et al. 1995; Barlow and Gerrodette 1996). However, neither estimate was corrected for the diving behavior of fin whales, and the winter estimate from aerial surveys is likely to be more seriously underestimated than the summer estimate from ship surveys.

The majority of the relatively few sightings in the Sea Range during spring, autumn, and winter were in the southern part of the Sea Range (Figure 3.7-50). During summer, on the other hand, sightings were scattered throughout the Sea Range, with a tendency for sightings to be more abundant in offshore waters north of Point Conception.

West of San Nicolas Island, the fin whale was the species of large whale most commonly encountered during NMFS/SWFSC surveys. Fin whales were encountered during all seasons, but were most frequently encountered during September to November (diamonds in Figure 3.7-50). Fin whales were commonly encountered west of San Nicolas Island during September-October of 1997 (Clark et al. 1998).

Although fin whales are found primarily on the continental slope and in offshore waters, they have been reported near San Nicolas, San Clemente, Santa Barbara, Santa Cruz, and Santa Rosa islands (Leatherwood 1987; Bonnell and Dailey 1993).

The initial pre-whaling population of fin whales in the North Pacific was estimated to include 42,000-45,000 whales (Ohsumi and Wada 1974). Currently, the best estimate for the California population is 933 (CV=0.27), based on ship-based surveys during summer of 1991 and 1993 (Barlow and Gerrodette 1996). This estimate may be negatively biased because it did not account for the diving behavior of fin whales; however, this bias is expected to be low for fin whales during ship surveys. Based on the method outlined in Section 3.7.1.5 (including allowance for diving behavior), about 1,477 fin whales occur within the Sea Range in summer (Table 3.7-5). This estimate may be high. The surveys that contributed to the estimate may have passed through a large concentration of fin whales in the Sea Range.

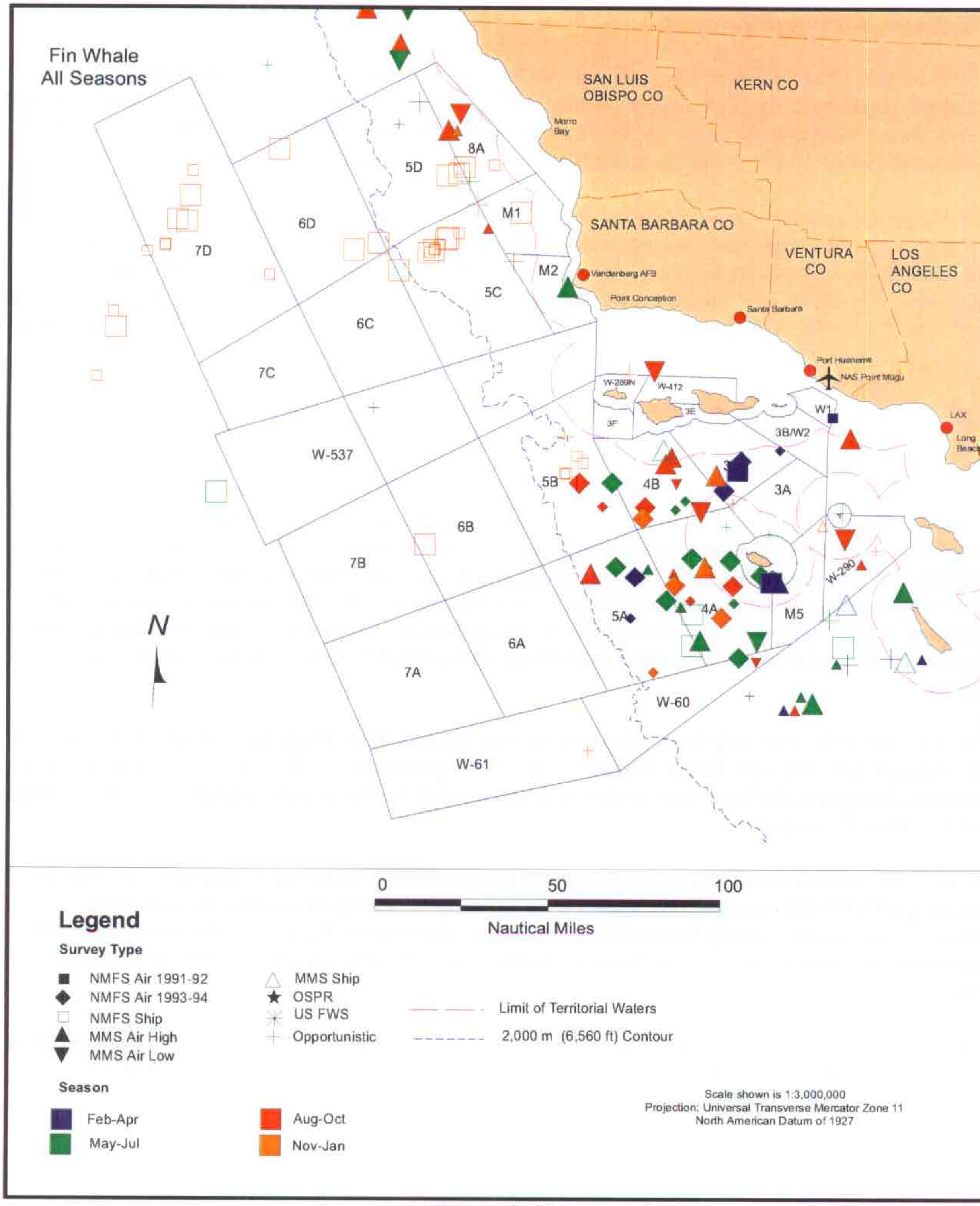


Figure 3.7-50

**Sightings of fin whales during the 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.**

Alternatively, because of interannual and seasonal fluctuations in numbers of fin whales in California waters, the best estimate of the California population size may come from years or seasons with less than maximal numbers in California waters. During winter, spring, and autumn, estimated totals of 262, 182, and 492 fin whales are present in the Sea Range, respectively. Most of these animals are found in non-territorial waters during winter (100 percent), spring (94 percent), and summer (100 percent); however, during autumn, 51 percent (253) of fin whales are in territorial waters (Table 3.7-5).

Fin whales are sometimes found singly or in pairs, but they are most often found in groups of three to seven individuals. Groups sighted in and near the Sea Range averaged 3.5 animals (n=95) when two large groups of 130 and 81 animals are excluded, and 5.6 when those groups are included. Fin whales feed on euphausiids, copepods, cephalopods, and small schooling fish.

In summary, the fin whale is listed as **endangered** and **depleted**, and the stock that occurs in the Sea Range is designated as a **strategic stock**. The population that occurs in the Point Mugu Sea Range winters offshore of Mexico and southern California and summers in the Sea Range and possibly as far north as Washington. This species is one of the most commonly encountered large cetaceans in the Sea Range. During summer, an estimated 1,477 fin whales (probably overestimated) are present in the continental slope and offshore areas of the Sea Range in non-territorial waters. During summer, the highest concentrations tend to be found in offshore waters north of Point Conception. During other times of year, an estimated 182 to 492 fin whales are present, primarily in the southern part of the Sea Range and primarily in non-territorial waters. This population appears to be increasing. Fin whales are generally found in small groups (average 3.5 individuals), but groups of 130 and 81 animals have been found in the Sea Range. They feed on euphausiids, copepods, squid, and small schooling fish.

Sei Whale, *Balaenoptera borealis*

The sei whale is federally listed as **endangered** under the ESA and is considered **depleted** and a **strategic stock** under the MMPA (Barlow et al. 1997). It is suspected that sei whales may have increased in abundance since whaling stopped in the mid 1960s but there are no quantitative data on population trends.

Sei whales are found in temperate waters worldwide (Bonnell and Dailey 1993), and are not usually associated with coastal features (Barlow et al. 1997). The IWC recognizes only one stock in the North Pacific (Donovan 1991), but there is some evidence for several different stocks.

Historically, sei whales occurred in the California Current off central California (37° to 39° north latitude) and they may have ranged as far south as the area west of the Channel Islands (32° 47' north latitude, Rice 1977). A few early sightings were made in May and June, but they were encountered in these waters primarily during July to September and had left California waters by mid-October. Shore-based whalers caught sei whales commonly off the California coast as recently as the 1950s and 1960s (Rice 1977). However, sei whales are rarely sighted in California waters now (Dohl et al. 1981; Barlow 1995; Forney et al. 1995).

Leatherwood et al. (1987) report two confirmed sightings south of the Sea Range, both in deep waters southwest of San Clemente Island. Three sightings have been made in the Sea Range during spring (June) and summer (August and September); they were in Sea Range Areas M1, M2, and 3D (south of the western tip of Santa Cruz Island). Recently, only one confirmed sighting of sei whales and five possible sightings (identified as either sei or Bryde's whales) were made in California waters during

extensive ship and aerial surveys during 1991-1993 (Mangels and Gerrodette 1994; Barlow 1995; Forney et al. 1995). The confirmed sighting was more than 200 NM (370 kilometers) off northern California.

The size of this population before whaling has been estimated at between 42,000 and 82,000 sei whales (Leatherwood et al. 1987). In 1974 the North Pacific population was estimated to contain 7,260 to 12,620 sei whales. There is no recent estimate of the size of the North Pacific population, and no abundance estimate is available for the putative stock inhabiting waters off California (Barlow et al. 1997). None to a few tens of sei whales may occur in the Sea Range primarily during spring and summer. They are most likely to occur in non-territorial waters. Due to the small California population size, any whales that are present may represent a significant fraction (possibly all) of the California population.

Sei whales generally occur in groups of two to five individuals, though larger groups may occur on the feeding grounds. The three groups seen in the Sea Range had two, two, and eight whales. They feed on copepods, euphausiids, amphipods, squid, and a variety of small schooling fish (Gambell 1985; Leatherwood and Reeves 1983).

In summary, the sei whale is listed as **endangered** and **depleted**, and the stock that occurs in the Sea Range is designated as a **strategic stock**. This species is rare in the continental slope and offshore areas of the Sea Range during spring and summer, and is not seen during other times of year. There is no estimate of the size of the stock that inhabits California waters, but the number must be small. None to a few tens of sei whales may occur in the Sea Range, primarily during spring and summer and primarily in offshore waters. Sei whales are generally found in small groups averaging two to five individuals. They feed on copepods, euphausiids, amphipods, squid, and small schooling fish.

Bryde's Whale, *Balaenoptera edeni*

Bryde's whale is not federally listed as endangered under the ESA and is not considered depleted or a strategic stock under the MMPA. It is the only species of large whale that was not heavily exploited by whalers.

Bryde's whales seen off the coast of California are likely part of a population that ranges from Baja California to Chile (Cummings 1985). This species is rarely seen in or near the Sea Range. None were sighted within the Sea Range during the numerous studies summarized here. Only one was positively identified during SWFSC aerial and ship surveys of California coastal waters during 1991 and 1993 (Barlow 1995; Forney et al. 1995; Barlow and Gerrodette 1996); it was just north of and farther offshore than the Sea Range (Hill and Barlow 1992). In addition, five possible sightings involving sei and/or Bryde's whales were also made during the SWFSC surveys.

The best estimate of the California population size is 24 (CV=2.0) (Barlow and Gerrodette 1996; Barlow et al. 1997). Given the low California population size, the number present on the Sea Range at any given time could range from none to the entire California population. Bryde's whales are more likely to be found in non-territorial waters but are occasionally sighted in nearshore areas.

Minke Whale, *Balaenoptera acutorostrata*

The minke whale is not federally listed as endangered under the ESA and is not considered depleted or a strategic stock under the MMPA (Barlow et al. 1998). The stock that inhabits offshore waters from Baja California to Washington has until recently been considered a **strategic stock** under the MMPA on the

assumption that the annual mortality due to human activities (primarily net fisheries) may not be sustainable (Barlow et al. 1997). However, its status was recently changed to "non-strategic" (NMFS 1998; Barlow et al. 1998).

Minke whales are found in tropical to sub-arctic waters worldwide. Although they are found both offshore and near the coast, they are found primarily over continental shelves in our area of concern (Jefferson et al. 1993; Barlow et al. 1997). Three stocks are recognized in the North Pacific: Sea of Japan/East China Sea, the rest of the western Pacific west of 180° west longitude, and the "remainder" of the North Pacific (Donovan 1991). In the Northeast Pacific, minke whales range from the Chukchi Sea south to Baja California (Leatherwood et al. 1987).

Minke whales occur year-round off California (Dohl et al. 1983; Barlow 1995; Forney et al. 1995). The minke whales found in waters off California, Oregon, and Washington appear to be resident in that area, and to have home ranges, whereas those farther north are migratory. On this basis it has been suggested that the Washington-to-California whales constitute a separate stock (Barlow et al. 1997).

On the other hand, minke whale abundance in the SCB fluctuates dramatically through the year, with spring and summer being the periods of greatest abundance (Dohl et al. 1981). Because of the apparent fluctuations in abundance, Bonnell and Dailey (1993) believed that some minke whales migrated northward through the southern part of the Sea Range in spring and returned southward through the same area in autumn. The data in Figure 3.7-51 suggest a migration into nearshore and continental slope areas south of the Sea Range in spring from areas either farther south or offshore, summer residence in the southeastern part of the Sea Range, and dispersion either offshore or south of the Sea Range during autumn. Leatherwood et al. (1987) suggested that minke whales may remain in the area throughout the year, and that the scarcity of sightings during autumn and winter may be due to behavioral and environmental considerations. The lack of sightings in autumn and winter may also be due to movements of minke whales into offshore areas where there has been less survey effort. The analyses summarized in Table 3.7-5 indicate that more minke whales probably inhabit offshore waters than nearshore waters despite the few offshore sightings.

The summer distribution has been described by Bonnell and Dailey (1993) and is illustrated in Figure 3.7-52. In summer, minke whales are commonly seen along the shelves associated with the southern coasts of the Channel Islands and offshore features south of there. Ship-based surveys during the summers of 1991 and 1993 seem to confirm the importance of the Sea Range for minke whales. Six of the eight sightings made during these two surveys were in or adjacent to the Sea Range (open squares in Figure 3.7-51).

Few minke whales are present in the southeastern part of the Sea Range during winter but they appear to be present in offshore waters. The few sightings in winter sometimes include newborn or small calves, suggesting that the southern part of the Sea Range is part of, or at least near, the calving grounds of this stock (Bonnell and Dailey 1993).

Barlow and Gerrodette (1996) estimated the population abundance for offshore California as a whole to be 201 (CV=0.65) based on ship-based surveys conducted during the summers of 1991 and 1993. This estimate may be negatively biased as no correction factor to account for the diving behavior of minke whales was used. No data on trends in abundance are available (Barlow et al. 1997). Based on the procedures described in Section 3.7.1.5 (including allowance for diving behavior), an average of 179 minke whales are estimated to be present in the Sea Range throughout the year (Table 3.7-5). About 12 percent (21 animals) are in territorial waters and 88 percent are in non-territorial waters. As mentioned

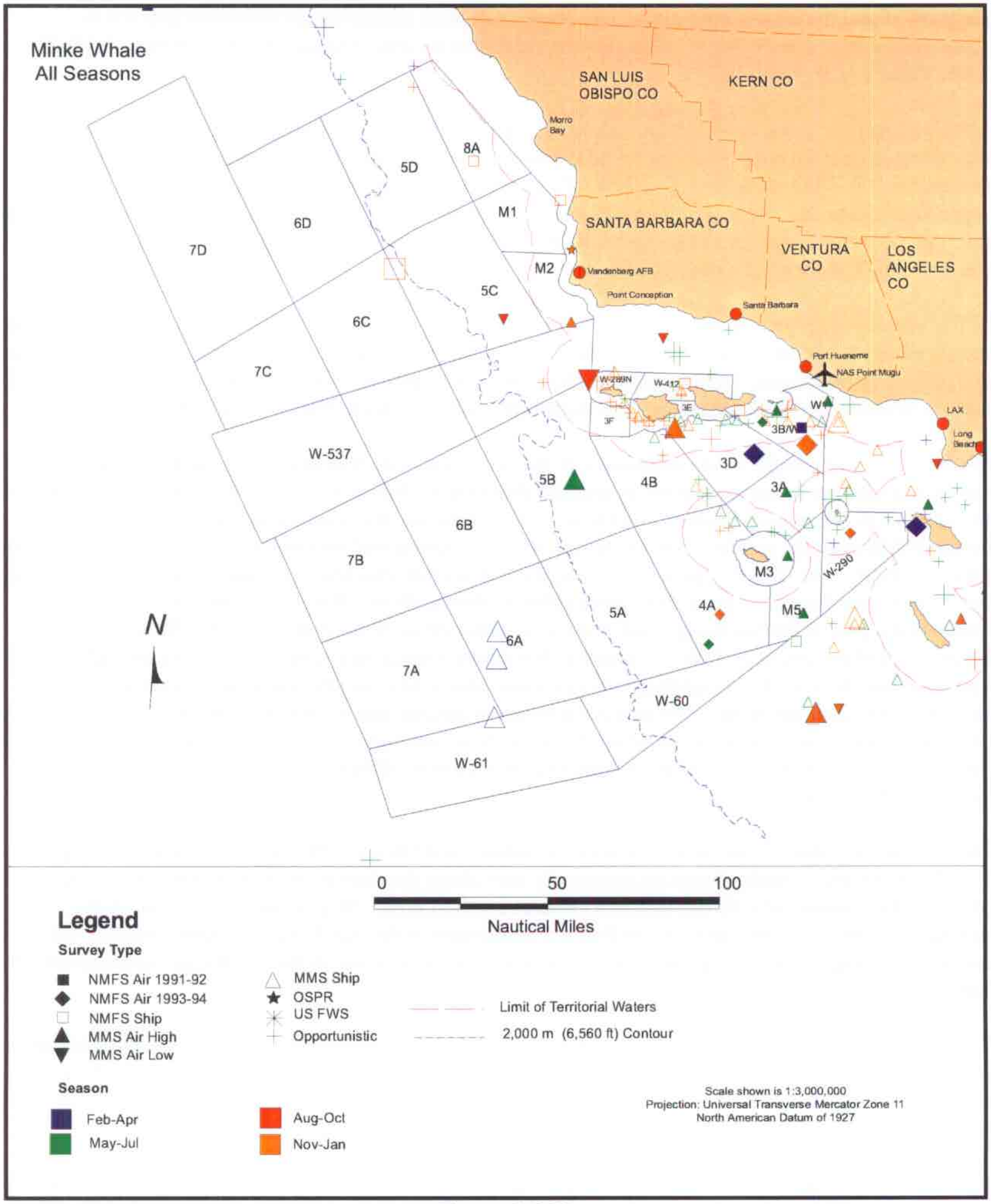


Figure 3.7-51
Sightings of minke whales during the 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

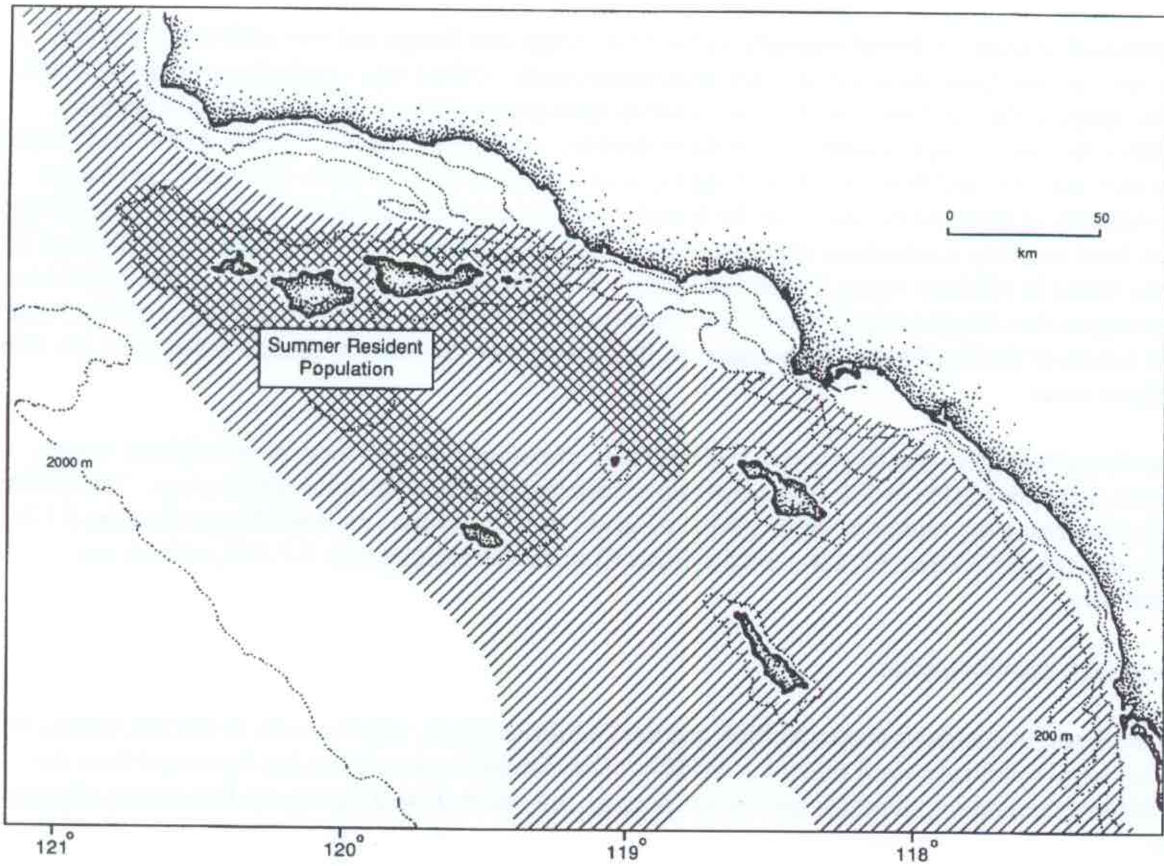


Figure 3.7-52
General seasonal distribution of minke whales in the Southern California Bight, 1975-78. From Bonnell and Dailey (1993).

above, the number and percentage in nearshore areas appears to increase during spring and summer, but there are too few data to estimate abundance separately by season.

Off California, minke whales are usually seen alone or in groups of two or three animals. The mean size of 89 groups seen in the Point Mugu Sea Range was 1.4 animals and the largest group was 17. Their diets in other areas are diverse, but within the Sea Range they probably feed on euphausiids and small shoaling fish. They are not known to make prolonged deep dives (Leatherwood and Reeves 1983).

In summary, minke whales found in the Sea Range are not endangered or depleted but until recently have been considered a **strategic stock**. Their seasonal distributions and movements are not well known because they are inconspicuous as compared with other baleen whales. Available data suggest that minke whales move into nearshore and continental slope waters of the southeastern part of the Sea Range during late spring and leave in late summer. During the remainder of the year they may disperse into offshore waters and possibly south of the Sea Range. During summer, many of the minke whales that inhabit offshore waters of California may be found in the southeastern part of the Sea Range, particularly south of and offshore of the Channel Islands. About 180 minke whales are present in the Sea Range throughout the year. Minke whales in the Sea Range usually occur in groups of one to three individuals (mean group size 1.4), and probably feed on euphausiids and small shoaling fish.

3.7.2.3 Pinnipeds

Four pinniped species are found regularly in the Point Mugu Sea Range and two additional species, Steller sea lion and Guadalupe fur seal, are seen occasionally. Of the four regularly-occurring species, only one species, the California sea lion, is common throughout offshore waters of the Sea Range throughout the year. Large numbers of northern elephant seals pass through offshore waters four times a year as they travel to and from breeding, pupping, and molting areas on islands within the Sea Range. Large numbers of northern fur seals may be found in offshore waters during the winter and spring when animals from northern populations may feed there. During the rest of the year, moderate numbers of fur seals are found in offshore waters of the Sea Range. They include only the animals that breed and raise their young on San Miguel Island. Moderate numbers of harbor seals are found hauled out on land and in coastal waters of the Sea Range, but because of their preference for shallow coastal waters, few are found in offshore areas.

This section emphasizes the distribution and activities of pinnipeds while they are in offshore waters. However, there are relatively few data on pinniped distribution and abundance while at sea. The details of their occurrence and numbers while ashore are given in later sections on Point Mugu (Section 3.7.3.3), San Nicolas Island (Section 3.7.4.3), and the Other Channel Islands (Section 3.7.5.3), and are not repeated here.

Harbor Seal, *Phoca vitulina*

The harbor seal is not listed under the ESA and the California stock, which occurs in the Sea Range, is not considered a strategic stock under the MMPA. The California population has increased from the mid-1960s to the present, although the rate of increase may have slowed during the last decade (Hanan 1996).

Harbor seals are considered abundant throughout most of their range from Baja California to the eastern Aleutian Islands. They are common and widely scattered in coastal waters and along coastlines in California. Over 850 haul-out sites are known for California and approximately 40 percent of known haul-out sites are occupied each year (Hanan 1996). The SCB is near the southern limit of the range of the Pacific harbor seal (Bonnell and Dailey 1993). In the Sea Range, harbor seals haul out and breed on all of the southern Channel Islands, as well as near the entrance to Mugu Lagoon. They generally favor sandy, cobble, and gravel beaches in this area (Stewart and Yochem 1994).

Most information on harbor seals comes from the periods when they are hauled out on land; however, over the period of a year they spend more time in the water than they do on land (Figure 3.7-53). Their distribution and movements while at sea are poorly known. The few sightings during aerial and ship-based surveys indicate that harbor seals are primarily found in coastal or nearshore areas (Figure 3.7-54). Recent studies using satellite-linked transmitters (deployed on only a few seals) have confirmed their primarily nearshore distribution and their tendency to remain near their haul-out sites (Figure 3.7-55).

In California, individual harbor seals remain relatively close to their haul-out sites throughout the year, and thus the abundance of harbor seals in offshore waters likely depends on the distance from suitable haul-out sites. A small number of seals (primarily juveniles) occasionally move between haul-out sites on different Channel Islands and on the mainland (Stewart and Yochem 1985). There are seasonal differences in the proportion of time that seals haul out and in the durations of foraging trips. The latter factor probably influences the distance that harbor seals can travel to and from their haul-out sites. There is age and sex segregation at haul-out sites and this may be true while they are at sea as well. Data

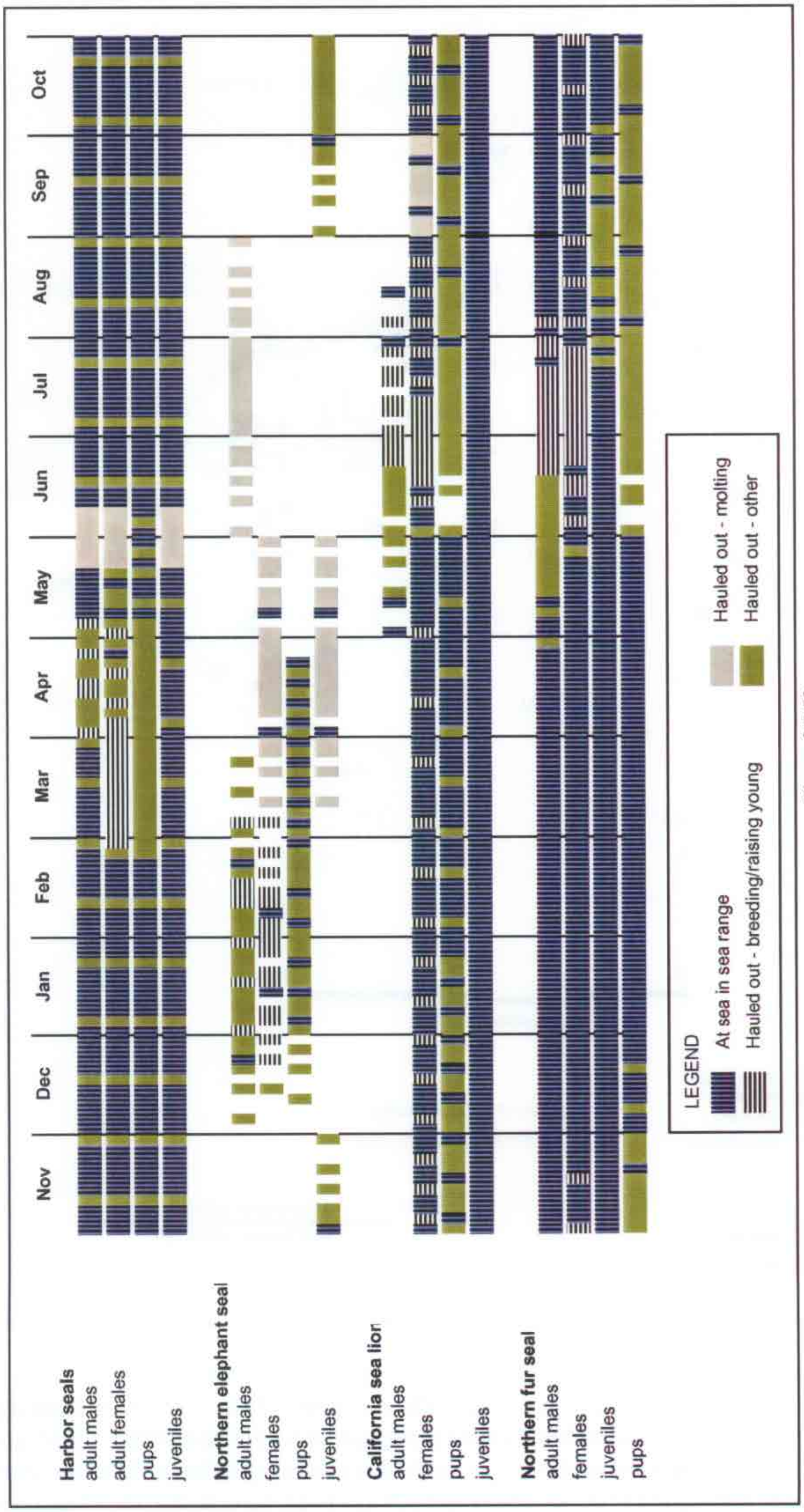


Figure 3.7-53

Activities of pinnipeds throughout the year in the Point Mugu Sea Range. Blanks indicate that animals are found outside of the Sea Range, or in the case of pups, that most pups are not born. Alternating activities indicate that not all animals are engaged in one activity. The width of each segment indicates approximate proportions of animals or of time engaged in each activity.

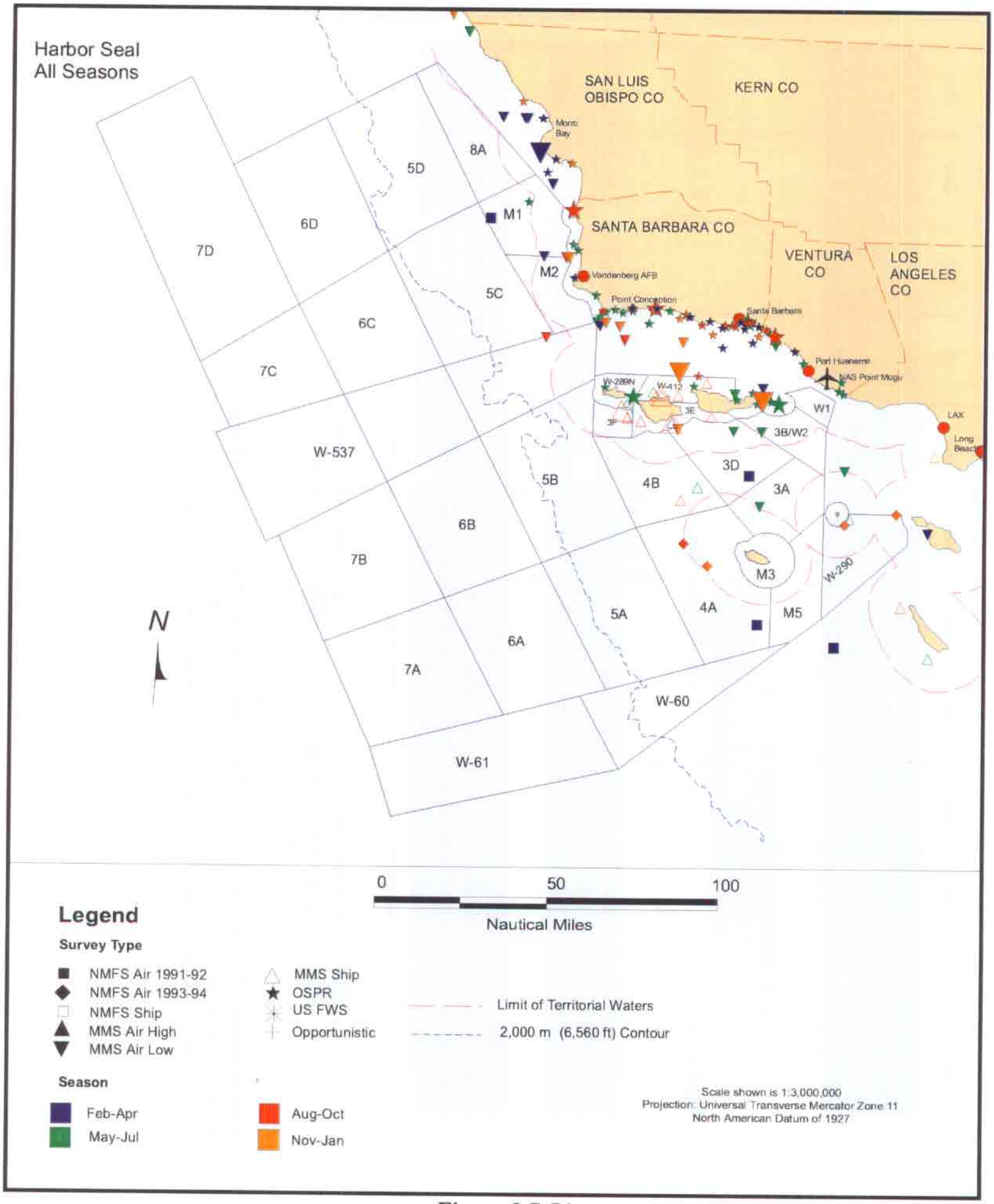


Figure 3.7-54

Sightings of harbor seals during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively. Harbor seals at sea are often inconspicuous during surveys, and have not always been recorded even when seen.

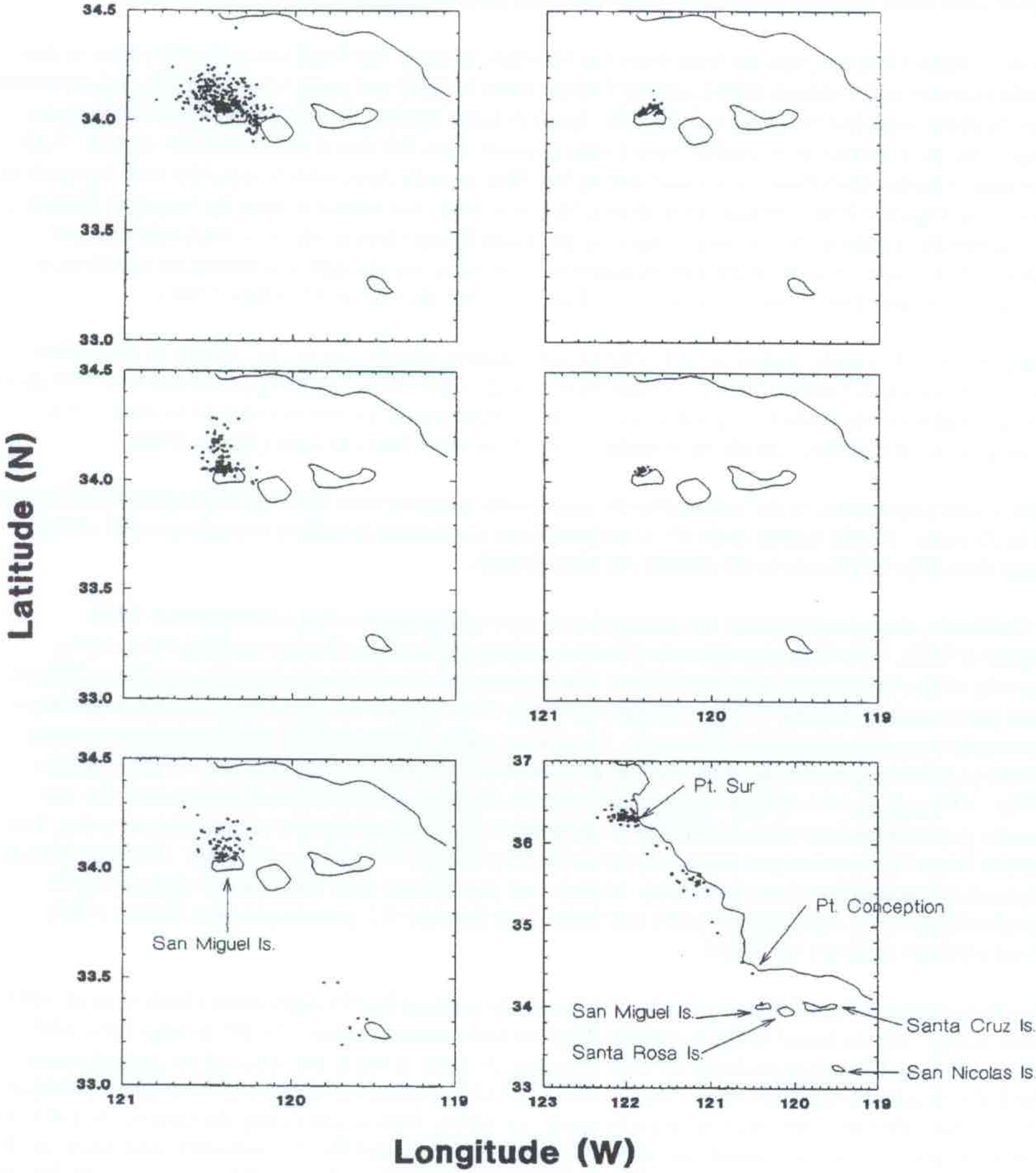


Figure 3.7-55
Foraging locations and movements of six harbor seals monitored by satellite-linked radio telemetry.
All seals were tagged at San Miguel Island. Each panel shows locations obtained for an individual seal. The seal that migrated north to Point Sur was a juvenile. From Stewart and Yochem (1994).

obtained from radio-tagged seals from the mainland and San Miguel Island indicate that most adult harbor seals leave haul-out areas daily even during the periods of peak haul out (Hanan 1996).

On the Channel Islands, pups are born from late February to early April and are nursed for three to four weeks (Stewart and Yochem 1994); estrous females mate in April and early May. Females and new-born pups haul out from late February to early May (peak in early April). Breeding takes place in the water. Males may have territories in coastal waters near haul-out sites, but this is not known for certain. Peak numbers of harbor seals haul out on land during late May to early June, which coincides with the peak of their molt (Figure 3.7-56). When at sea during May and June (and March to May for breeding females), they generally remain in the vicinity of haul-out sites and forage close to shore in relatively shallow waters. At all times of year, maximum numbers of seals are at sea at night and maximum numbers are hauled out on land from 13:00 to 16:00 hours (Figure 3.7-56; Stewart and Yochem 1994).

Numbers of harbor seals hauled out at terrestrial sites decline sharply during the August to December period (Stewart and Yochem 1994). During these months seals are at sea for approximately 90 percent of the time and may make week-long excursions to sea. These longer excursions may be to deep-water feeding areas, or possibly include movements to and from other haul-out sites (Hanan 1996).

Harbor seal populations in the eastern Pacific near North America have increased substantially in the last 30 to 35 years. Pacific harbor seals (*P. v. richardsi*) are considered abundant throughout most of their range from Baja California to the eastern Aleutian Islands.

In California, the rate of increase has changed over time and appears to have slowed since 1990 (Figure 3.7-57). This indicates either that harbor seal populations may be approaching the carrying capacity of the environment (Hanan 1996) or that harbor seals are being displaced by northern elephant seals (Mortenson and Follis 1997). Populations of the latter species are expanding into areas that were previously occupied solely by harbor seals. For harbor seals, southern California has the lowest mean annual population growth rate of the three regions within California (1.9 percent, SE = 0.013; Hanan 1996). Although the overall population within the Sea Range has been relatively stable over the last decade, populations have remained stable or declined on San Miguel Island (-1.2 percent per year), San Nicolas Island (0.0 percent per year), and Santa Barbara Island (-1.0 percent per year). On these islands, elephant seal populations have increased. Harbor seal populations have continued to grow on Santa Catalina Island (+11.2 percent per year) and Santa Cruz Island (+5.7 percent per year; Hanan 1996), where elephant seals are not found.

The best estimate of the California stock of harbor seals is about 30,293 individuals (Barlow et al. 1997; Table 3.7-2). This is based on the most recent harbor seal counts on shore (23,302 in May-June 1995, Hanan 1996) and a correction factor of 1.3 to account for seals at sea at the times of the coastal counts. The California stock size may range from 28,000 to 35,650 if correction factors of 1.2 (Hanan 1996) or 1.53 (Huber 1995) are more appropriate to account for harbor seals at sea during the counts. In 1995, the total count for the Channel Islands was 3,005 individuals. The count for the mainland coast south of 35° N was an additional 1,200 harbor seals (Hanan 1996). Based on the 1.3 correction factor used by Barlow et al. (1997), the total harbor seal population in these areas in 1995 was about 3,907 plus 1,560 seals. The population in the Channel Islands may be as low as 3,600 or as high as 4,600 harbor seals if the correction factors of Hanan (1996) and Huber (1995) are more appropriate. Harbor seals are difficult to detect during ship-based or aerial surveys because of their inconspicuous behavior when at sea. Estimates of about 914, 2,860, 927, and 2,065 harbor seal were obtained for the Sea Range in winter, spring, summer, and autumn, respectively, using the procedures described in Section 3.7.1.5. The estimates for winter, spring, and autumn are consistent with haul-out patterns given in Figure 3.7-53.

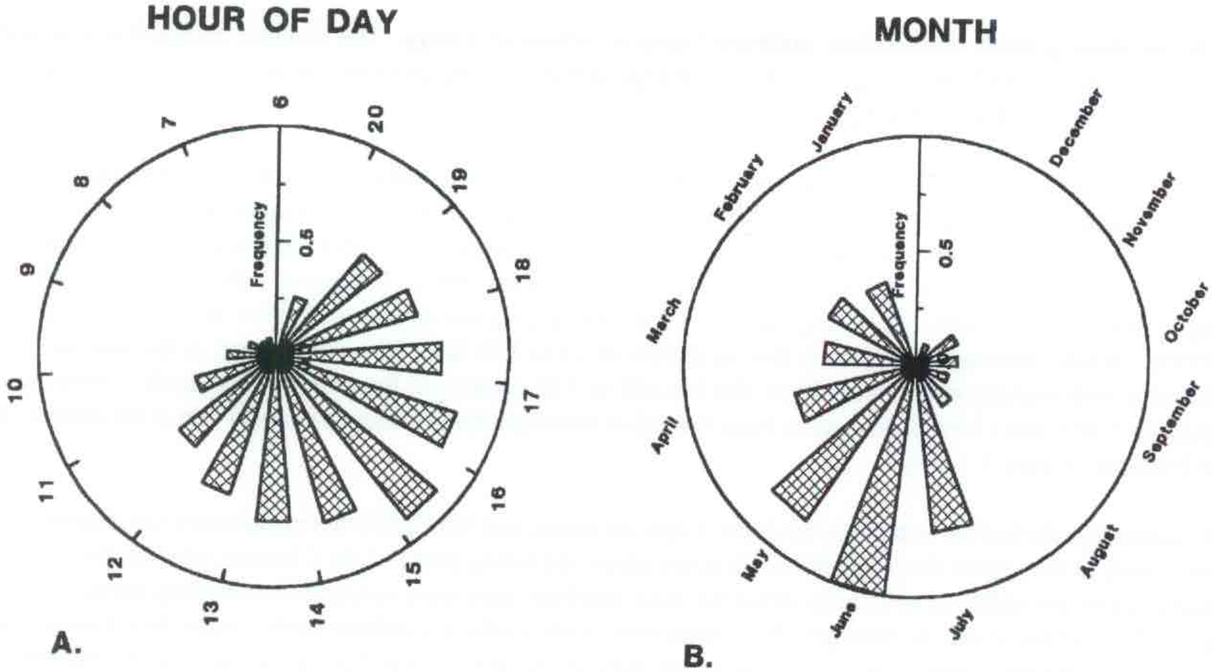


Figure 3.7-56
Abundance of harbor seals at terrestrial haul-out sites on the Channel Islands on *(A)* an hourly basis during the day and *(B)* a monthly basis during the year.
From Stewart and Yochem (1994).

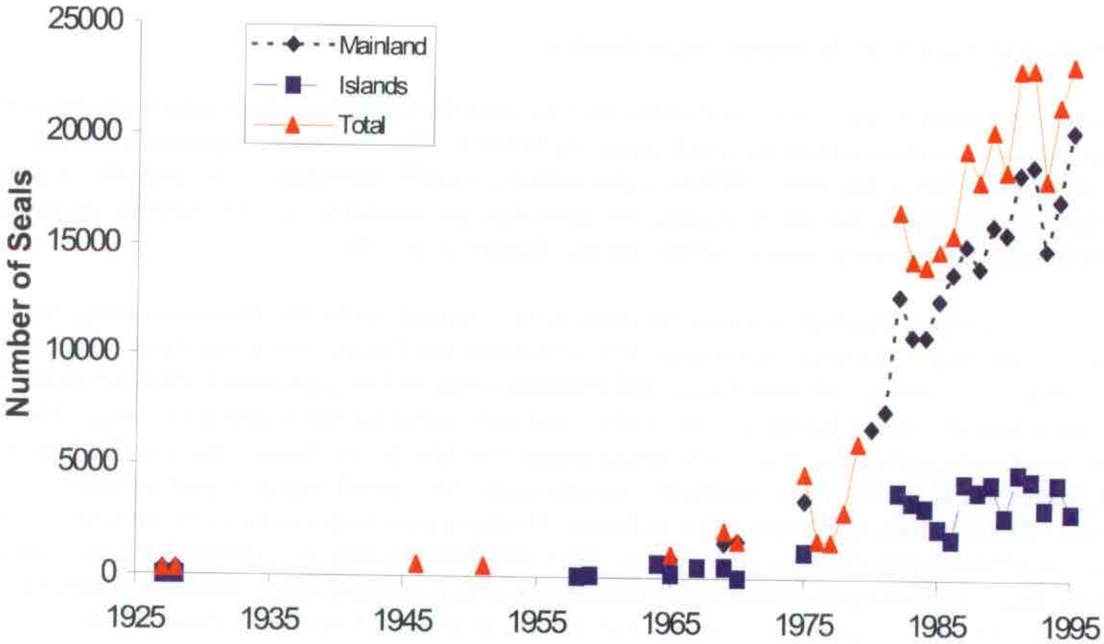


Figure 3.7-57
Counts of harbor seals in California, 1927-95.
Plotted from data in Table 1 of Hanan (1996).

During these periods most harbor seals are found in territorial waters. The summer estimate is low; most of the 3,600 to 4,600 harbor seals in the Sea Range population are probably present in non-territorial waters of the Sea Range during summer.

Thirty-seven species of fish, ten species of cephalopods, and one crustacean have been identified as prey of harbor seals from the Channel Islands (Stewart and Yochem 1994). Their most common prey species include rockfish, spotted cusk-eel, octopus, plainfin midshipman, and shiner surfperch, which seals capture in nearshore waters (Table 3.7-2; Stewart and Yokem 1994). In central California, topsmelt, night smelt, white croaker, and English sole were also major prey species of harbor seals (Harvey et al. 1995). While feeding, harbor seals dive to depths of 33 to 130 feet (10 to 40 meters) in the case of females with nursing pups, and 260 to 390 feet (80 to 120 meters) in the case of other seals. Dives as deep as 1,463 feet (446 meters) have been recorded although dives greater than 460 feet (140 meters) are infrequent (Figure 3.7-58).

In summary, the harbor seal does not have a special status and the California population has dramatically increased in size since the mid-1960s. In some areas, including parts of the Channel Islands, the populations are stable or declining either because numbers may have reached the carrying capacity of the available habitat or due to interspecific competition with northern elephant seals. Individual harbor seals spend considerably more time in the water than they do on land except during the molting period, which peaks in late May to early June and, for adult females, during the pupping and nursing period from late February to mid-May. The California stock includes 28,000 to 35,650 seals, of which 3,600 to 4,600 inhabit coastal haul-out sites and waters in the Point Mugu Sea Range. During most of the year they remain near their haul-out sites. Most feeding occurs in nearshore waters 33 to 130 feet (10 to 40 meters) deep (nursing females) or 260 to 390 feet (80 to 120 meters) deep (others). Their diet consists of rockfish, spotted cusk-eel, octopus, plainfin midshipman, and shiner surfperch.

Northern Elephant Seal, *Mirounga angustirostris*

The northern elephant seal is not listed under the ESA and the California stock, which occurs in the Sea Range, is not considered a strategic stock under the MMPA. The California population has recovered from near extinction in the early-1900s to approximately 84,000 individuals. The population growth rate may have slowed during the last five years, but more data are needed to confirm whether the population is approaching the carrying capacity of the habitat (Barlow et al. 1997).

Historically, northern elephant seals are believed to have hauled out by the thousands along the coast of California and Baja California (Scammon 1874 *in* Bonnell and Dailey 1993), but there is little or no documentation of their actual distribution and breeding range before exploitation (Stewart et al. 1993). They were heavily hunted during the last century and were subsequently reduced to a single breeding colony numbering perhaps as few as a hundred animals on Isla de Guadalupe, Mexico (Barlow et al. 1993; Stewart et al. 1994). Now, northern elephant seals molt, breed, and give birth primarily on offshore islands in Baja California and California. Rookeries are found as far north as South Farallon Islands and Point Reyes (Barlow et al. 1993). The California population is demographically isolated from the Baja California population and is considered to be a separate stock, although genetically the two populations are indistinguishable (Barlow et al. 1997). Within the Sea Range about two-thirds of the elephant seals haul out on San Miguel Island, about 32 percent on San Nicolas Island, and small numbers on Santa Rosa (1 percent), Santa Cruz, Anacapa, and Santa Barbara islands.

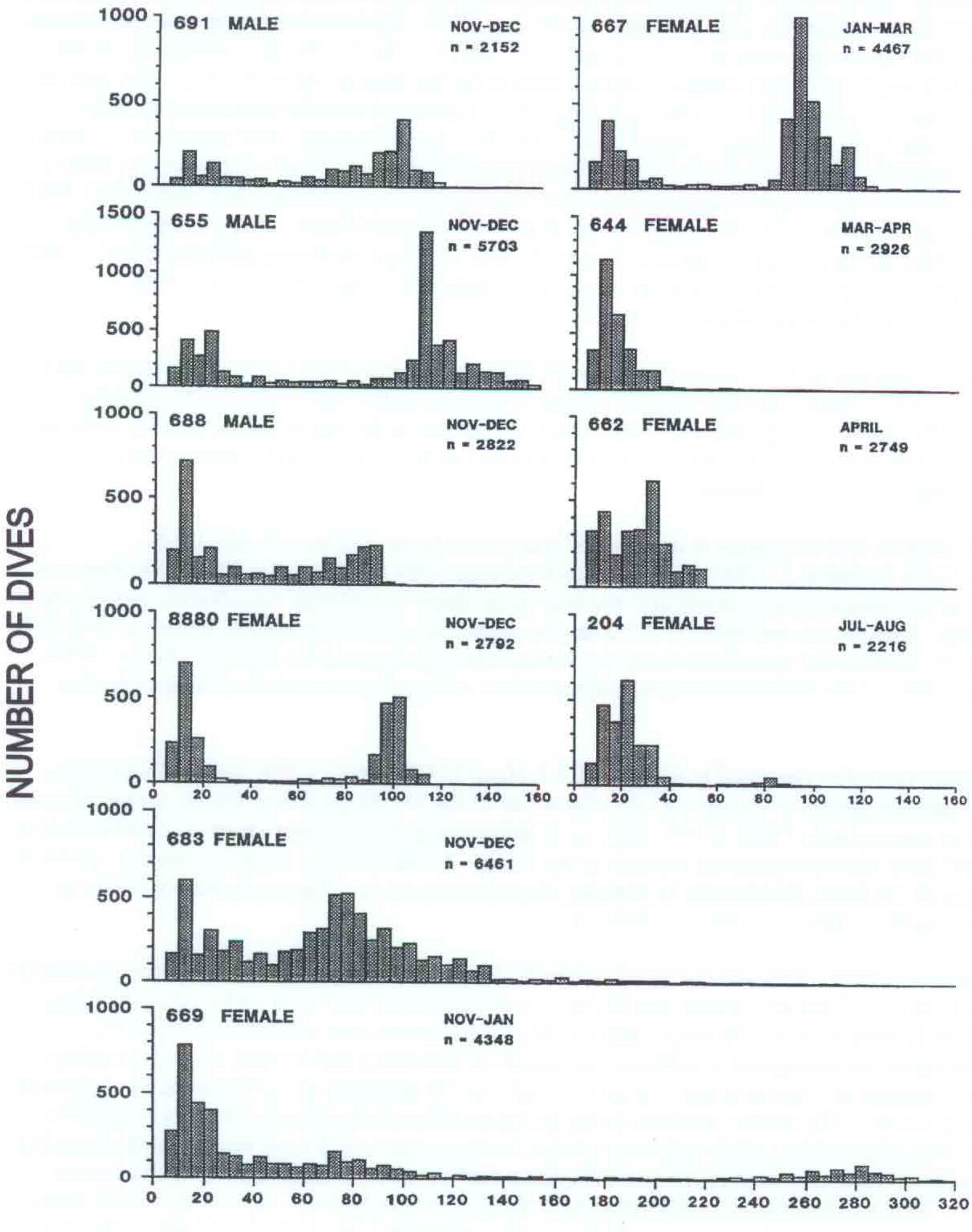


Figure 3.7-58
Depths of foraging dives of harbor seals near the Channel Islands.
From Stewart and Yochem (1994).

Adult northern elephant seals spend from eight to ten months at sea and undertake two annual migrations between haul-out and feeding areas (Stewart and DeLong 1995). Their movements between these areas are rapid. They spend little time in coastal or nearshore waters of the Sea Range, as evidenced by the relatively few sightings during surveys of marine areas in the Sea Range (Figure 3.7-59). They haul out on land to give birth and breed, and after spending time at sea to feed (postbreeding migration), they generally return to the same areas to molt (Odell 1974; Stewart and Yochem 1984; Stewart 1989; Stewart and DeLong 1995). However, they do not necessarily return to the same beach. In the South Farallon Islands, female northern elephant seals often molt on one island and breed on another (Huber et al. 1991). After molting, they undertake a second prolonged foraging migration (Figure 3.7-60). Elephant seal activities while hauled out are described in Section 3.7.4.3, later, and are shown in Figure 3.7-53. Their brief periods of movement through the Sea Range occur during the times of year with vertical interruptions in the bar graphs shown in Figure 3.7-53.

While at sea, elephant seals are usually found well offshore and north of the Sea Range. Females feed between 40° and 45° north latitude, and males range as far north as the Gulf of Alaska (Stewart and DeLong 1995; Figure 3.7-60). Pups are weaned and abandoned on the beaches when they are about one month old (Odell 1974; Le Boeuf and Laws 1994) and they go to sea when one to three months old. Their distribution at sea is unknown.

Northern elephant seal abundance in the Channel Islands has increased since the mid-1960s (Figure 3.7-61; Barlow et al. 1993). Presently the California stock is estimated at 84,000 (Barlow et al. 1997). On the Channel Islands in and near the Sea Range, about 20,267 pups were born in 1995 (Lowry et al. 1996). Based on the multiplier of 3.5 times the annual pup production used by Barlow et al. (1997), the northern elephant seal population in the Sea Range was approximately 71,000 individuals in 1995. Thus about 85 percent of the California northern elephant seal population used the islands in the Sea Range.

Based on the procedure described in Section 3.7.1.5, about 26,623, 6,495, 7,409, and 11,356 northern elephant seals are present in coastal and offshore waters of the Sea Range during winter, spring, summer, and autumn, respectively (Table 3.7-5). These estimates exclude the seals that are on land within the Sea Range and those that have migrated outside the Sea Range. These estimates are quite imprecise given the limitations of aerial and ship surveys in detecting elephant seals at sea. (Elephant seals are below the surface about 90 percent of the time-see below.)

The estimated numbers of elephant seals present in the Sea Range during each season reflect the seasonal movements of seals between northern feeding areas and the haul-out sites used for breeding, pupping, and molting (Figure 3.7-53). The large numbers (26,623) estimated to be present in waters of the Sea Range during winter correspond to offshore movements of both males and females from the breeding colonies, the return of females to haul-out sites to molt, and (in nearshore areas) the initial forays by pups into coastal waters. The smaller numbers during spring (6,495) include females returning to offshore waters to feed after molting, adult males returning to haul-out sites to molt after feeding north of the Sea Range, and (in nearshore waters) pups dispersing from haul-out sites. In summer, the small numbers present (7,409) include adult males dispersing to feeding areas from haul-out sites and juveniles returning to haul-out areas to molt. The moderate numbers during autumn (11,356) include juveniles returning to feeding areas north of the Sea Range and adult males and females returning to breeding and pupping sites.

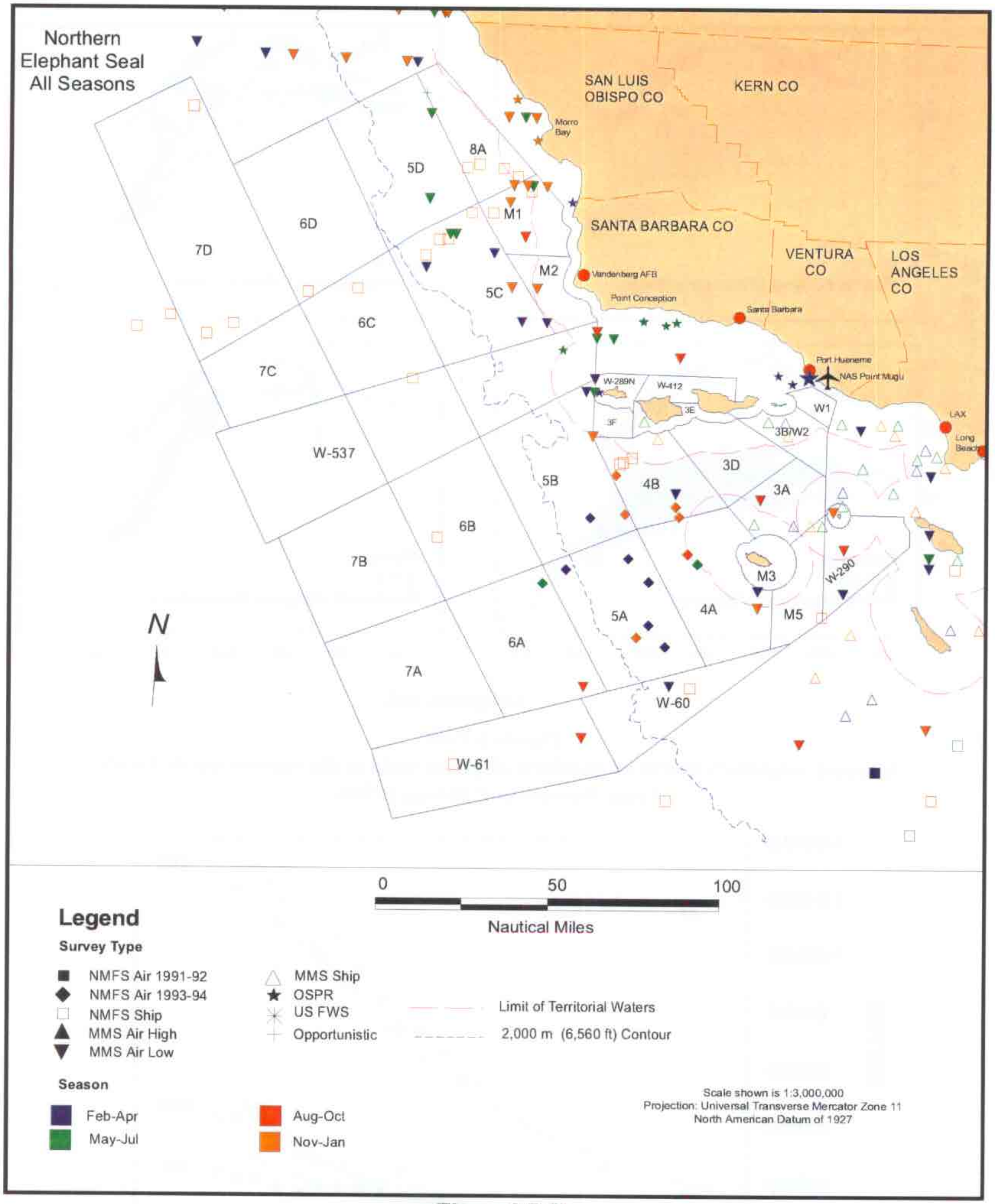


Figure 3.7-59

Sightings of northern elephant seals during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively. Elephant seals are especially difficult to survey because they are below the surface most of the time.

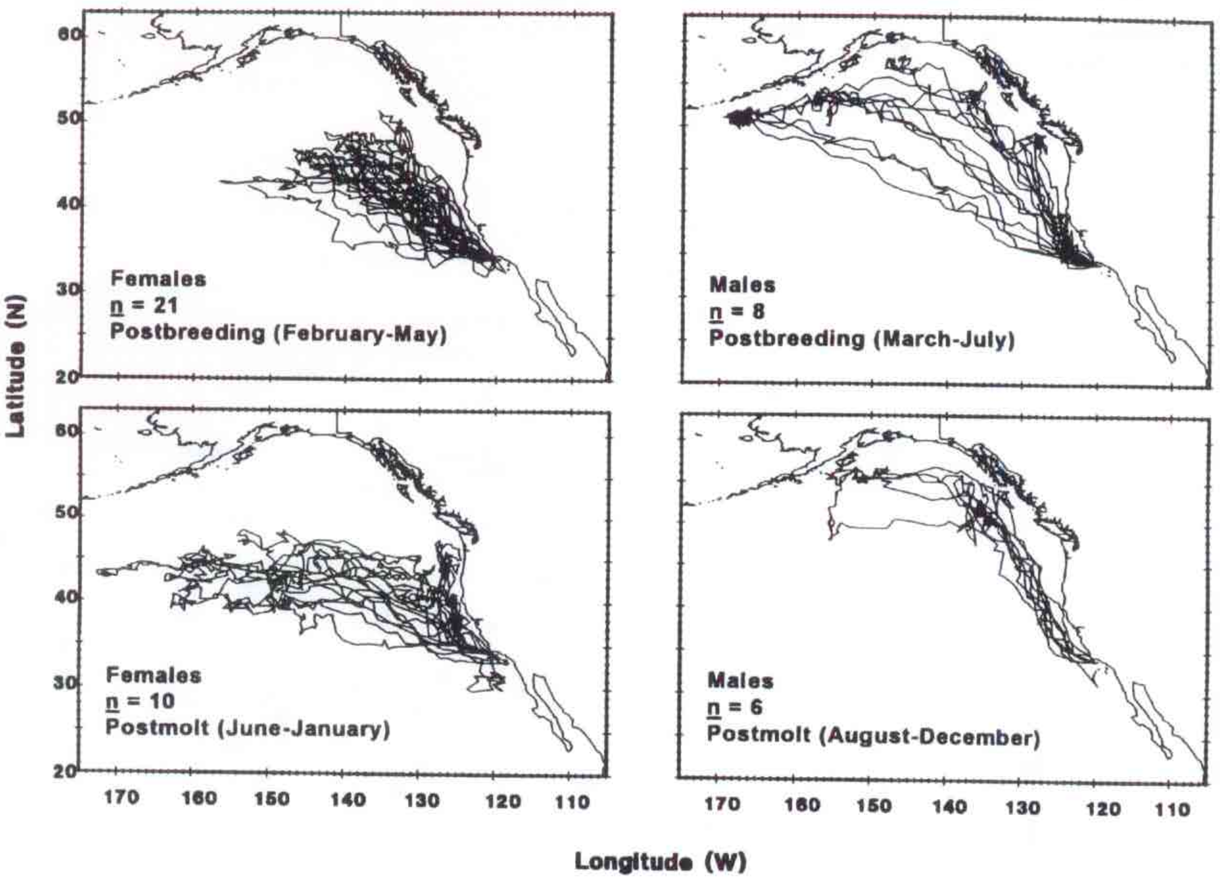


Figure 3.7-60
Seasonal migratory tracks of northern elephant seals in the eastern north Pacific. From Stewart and Delong (1995).

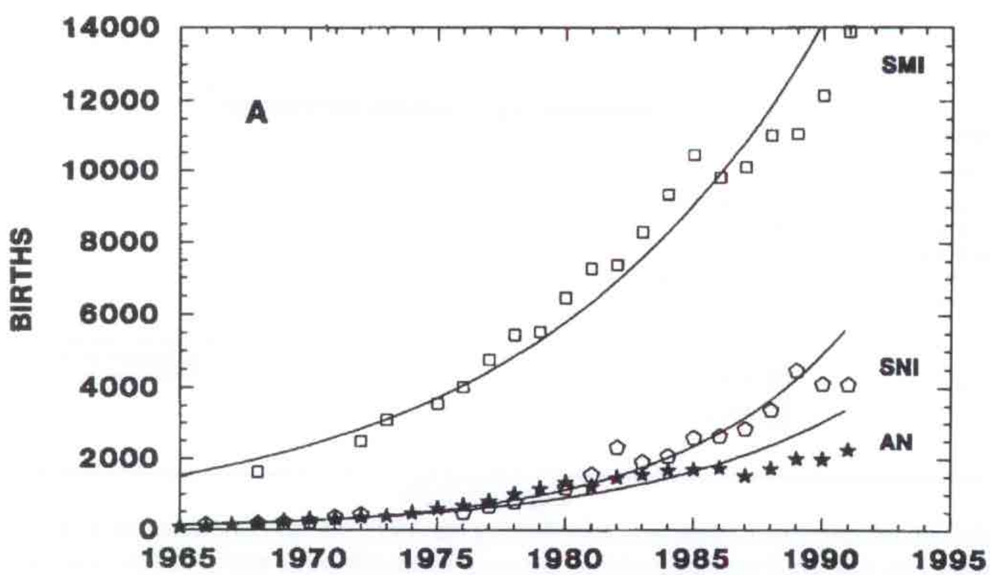


Figure 3.7-61
Growth of the northern elephant seal population as indicated by births at San Miguel Island (SMI), San Nicolas Island (SNI) and Año Nuevo Island (AN). From Stewart et al. (1994).

In non-territorial waters within the Sea Range, the largest estimated number of elephant seals (17,401) is found during winter (Table 3.7-5). In territorial waters of the Sea Range, the largest estimated number of elephant seals (9,221) is also found in winter.

Most feeding occurs outside of the Sea Range. While adults are at sea they feed almost continuously. Both sexes routinely dive deeply (492 to 2,625 feet [150 to 800 meters]); dives average 15 to 25 minutes in duration, depending on time of year, and surface intervals between dives are two to three minutes. The deepest dives recorded for both sexes are over 5,000 feet (1,524 meters) (Table 3.7-2). Females remain submerged about 86 to 92 percent of the time and males about 88 to 90 percent (Le Boeuf et al. 1988; Stewart and DeLong 1993, 1995). Feeding juvenile northern elephant seals dive for slightly shorter periods (13 to 18 minutes), but they dive to similar depths (980 to 1,480 feet [300 to 450 meters]) and spend a similar proportion (86 to 92 percent) of their time submerged (Le Boeuf et al. 1996).

Thirty different species have been identified as prey of northern elephant seals; however, bottom-dwelling fishes and squid are their primary prey (Hacker 1986; Antonelis et al. 1990). Other common prey items are listed in Table 3.7-2.

In summary, northern elephant seals do not have a special status, and the California population has dramatically increased in size since the early 1900s. They spend 8 to 10 months of the year feeding in offshore waters north of the Sea Range, and most of the remaining time hauled out on beaches where they give birth to pups, breed, and molt. They migrate through the Sea Range four times a year during movements to and from haul-out sites. The California stock is estimated to be approximately 84,000 seals of which about 71,000 (85 percent) use islands within the Sea Range. Two thirds of the seals in the Sea Range use haul-out sites on San Miguel Island, 32 percent use San Nicolas Island, and small numbers use Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara islands. Maximum numbers are present at sea in the Sea Range during winter, and lowest numbers occur there during spring and summer. Different age and sex categories have somewhat differing annual cycles and different migration patterns. Almost all feeding occurs outside of the Sea Range on bottom-dwelling fishes, squid, and numerous other prey species. Elephant seals routinely dive to 492 to 2,625 feet (150 to 800 meters) to feed and spend two to three minutes on the surface after dives lasting 21 to 25 minutes.

California Sea Lion, *Zalophus californianus*

The California sea lion is not listed under the ESA and the U.S. stock, which occurs in the Sea Range, is not considered a strategic stock under the MMPA. The U.S. stock has increased from the early 1900s to the present, and since 1983 the annual rate of increase has been 8.3 percent (Barlow et al. 1997; Figure 3.6.62).

The California sea lion includes three subspecies:

- *Zalophus californianus wollebaeki* (in the Galapagos Islands),
- *Z. c. japonicus* (formerly in Japan, thought to be extinct), and
- *Z. c. californianus* (from southern Mexico to southwestern Canada) (Barlow et al. 1997).

Z. c. californianus is subdivided into three stocks (U.S., Western Baja California, and Gulf of California) based on genetic differences and geographic separation. Although there has been some interchange between the U.S. and Western Baja California populations, the breeding locations are far apart and they are considered separate stocks for management purposes. Most of the U.S. stock (more than 95 percent) breeds and gives birth to pups on San Miguel, San Nicolas, and Santa Barbara islands, which are in the

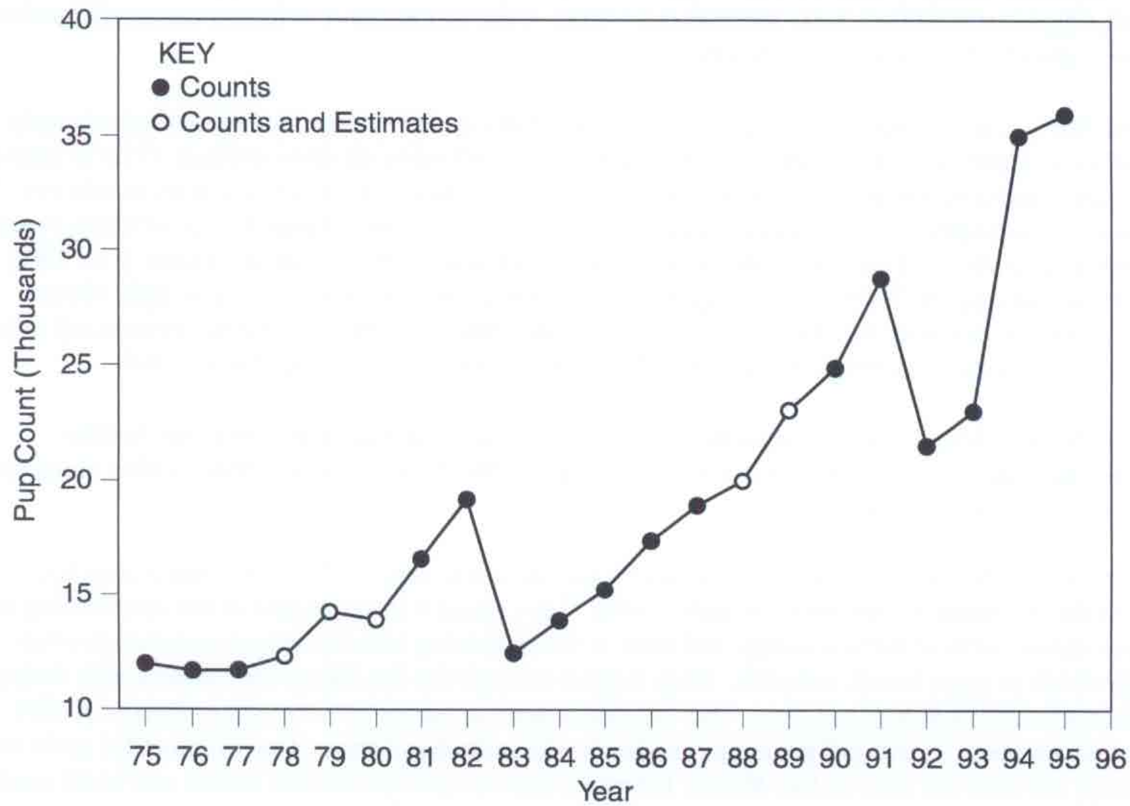


Figure 3.7-62
Index of California sea lion pup counts for the U.S. stock, 1975-95.
From Barlow et al. (1997).

Sea Range. Smaller numbers of pups are born on San Clemente Island (south of the Sea Range) and the Farallon Islands and Año Nuevo Island (north of the Sea Range).

The California sea lion is by far the most commonly sighted pinniped species at sea in the Sea Range. Sea lions made up 84 percent (2,137 of 2,538) of identified pinniped sightings at sea during the studies summarized in Table 3.7-3. They were sighted during all seasons and were sighted in all areas with survey coverage from nearshore to offshore areas (Figures 3.7-63 to 3.7-66).

Bonnell and Ford (1987) analyzed survey data from 1975 to 1978 to describe the seasonal shifts in the offshore distribution of California sea lions. During summer, the highest densities were found immediately west of San Miguel Island (Figure 3.7-67). During autumn, peak densities of sea lions were centered around Santa Cruz Island (Figure 3.7-68). During winter and spring, peak densities occurred just north of San Clemente Island (Figure 3.7-69). Bonnell and Ford (1987) attributed these seasonal changes in the center of distribution to changes in the distribution of the prey species. If California sea lion distribution is determined primarily by prey abundance, these same areas might not be the center of sea lion distribution every year.

The distribution and habitat use of California sea lions vary with the sex of the animals and their reproductive phase. Adult males haul out on land to defend territories and breed from mid-to-late May until late July. Individual males remain on territories for 27 to 45 days without going to sea to feed.

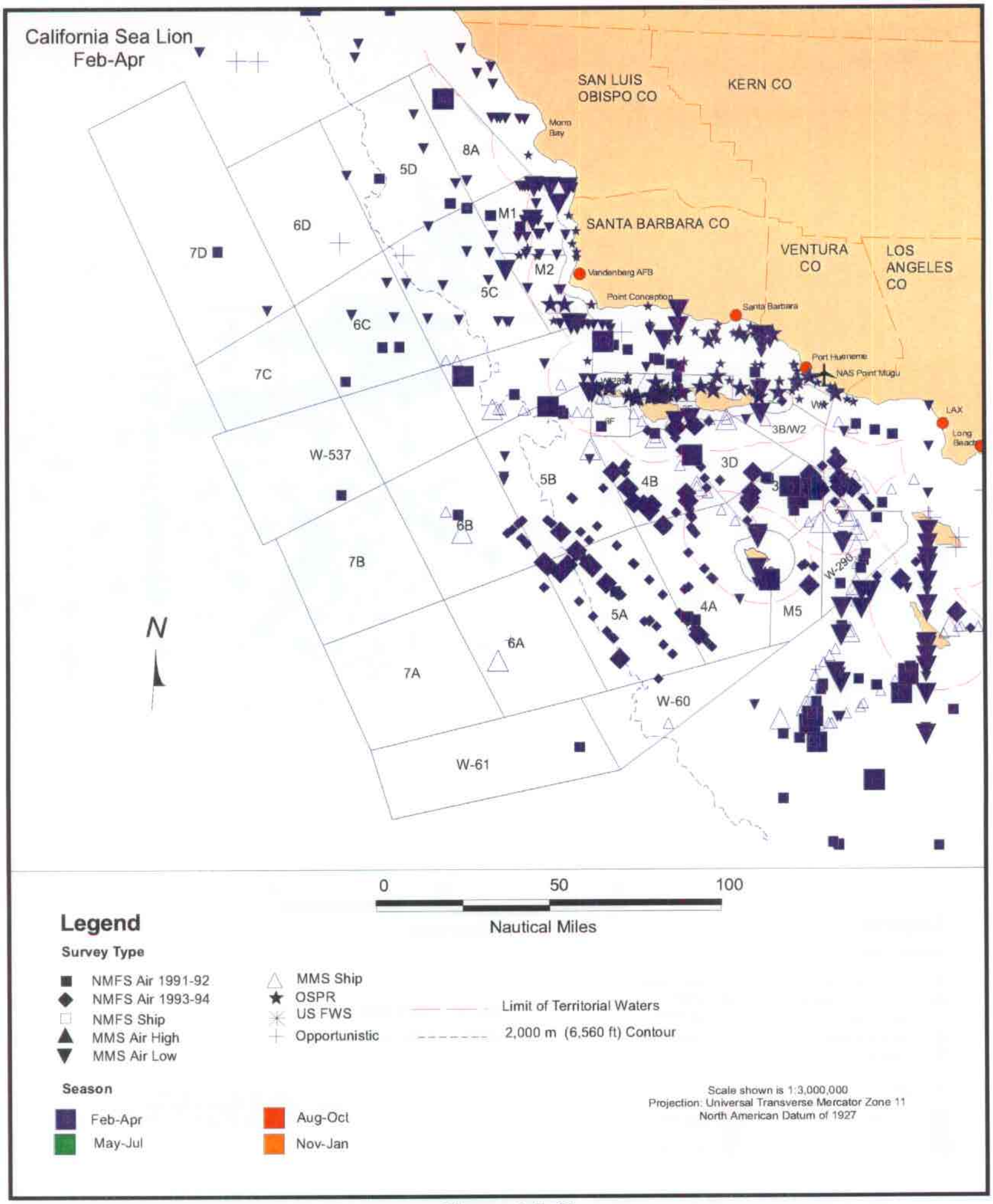


Figure 3.7-63

Sightings of California sea lions during the February-April 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

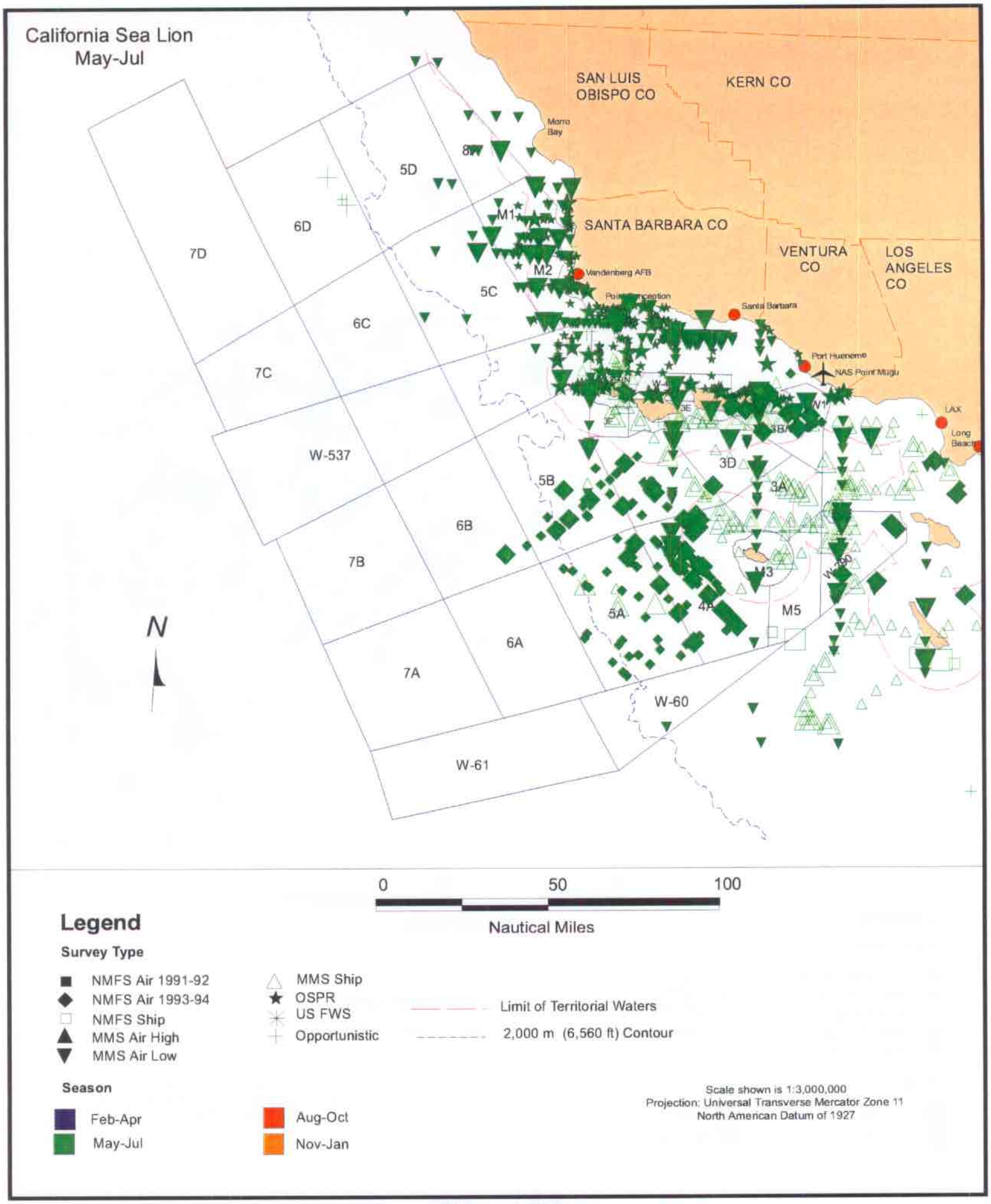


Figure 3.7-64

Sightings of California sea lions during the May-July 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

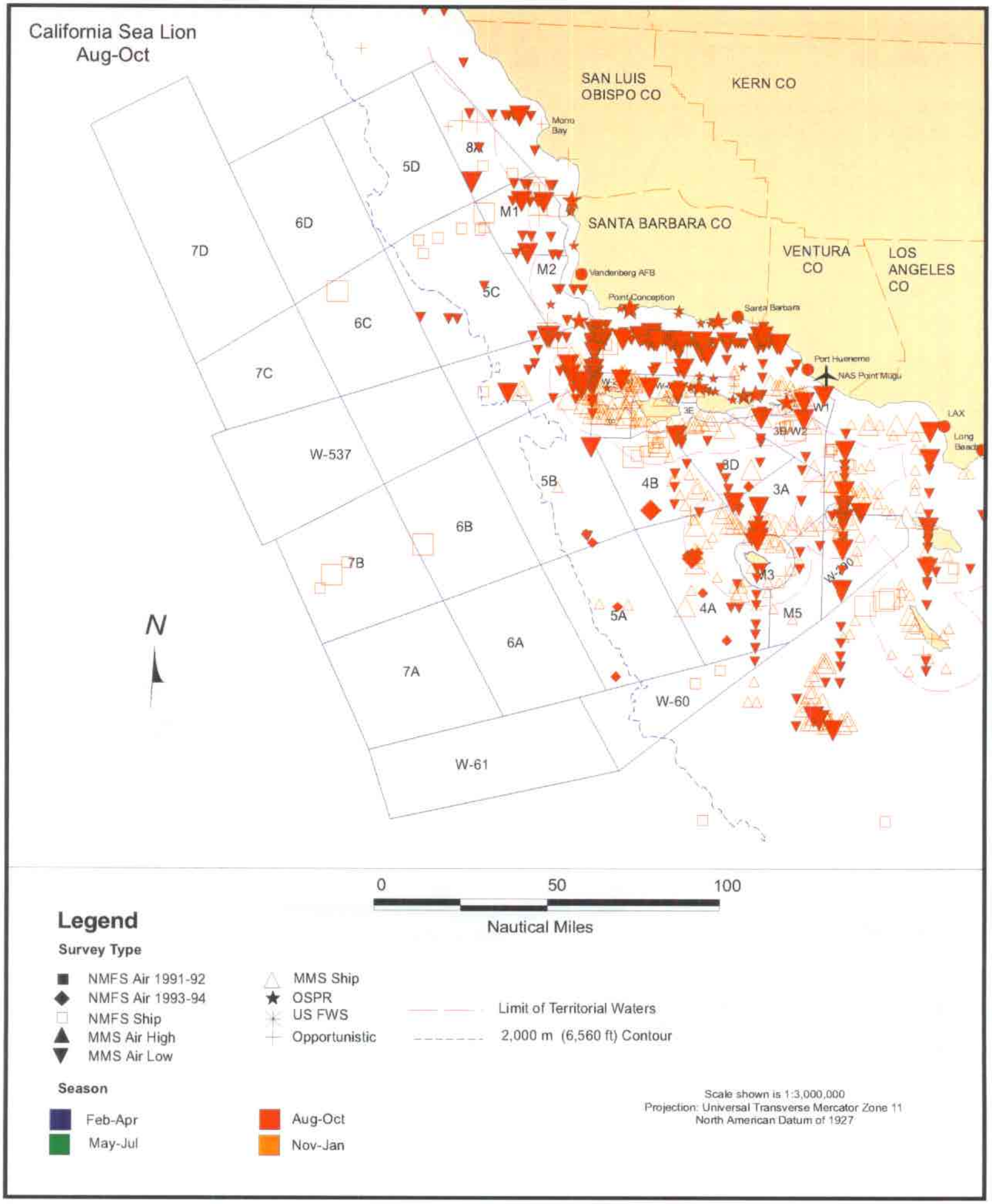


Figure 3.7-65

Sightings of California sea lions during the August-October 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

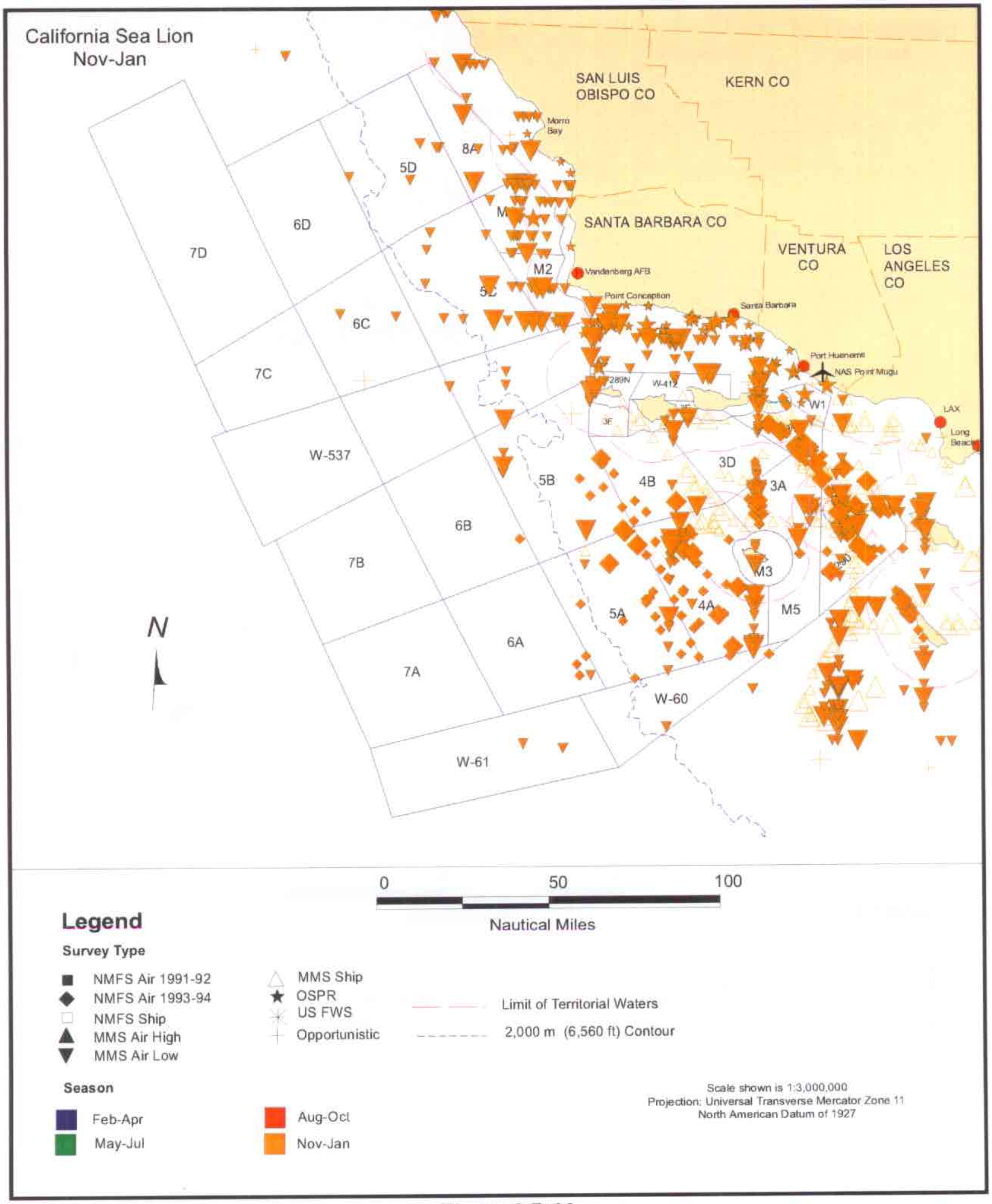


Figure 3.7-66

Sightings of California sea lions during the November-January 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

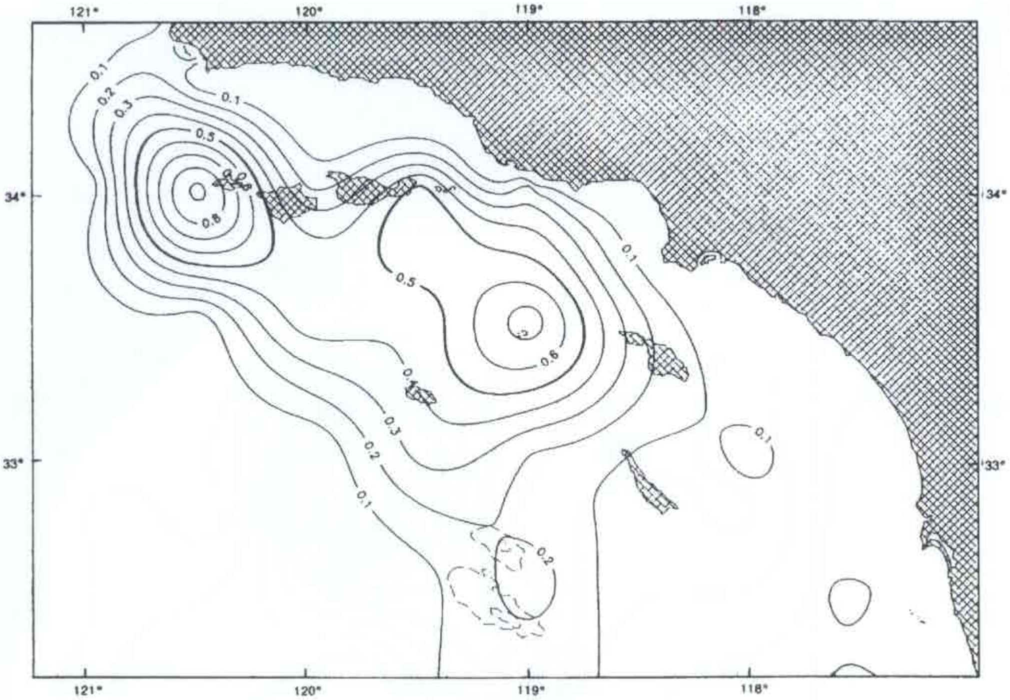


Figure 3.7-67
California sea lion distribution (animals/km^2) in the Southern California Bight during the breeding season (Jun-Aug), 1975-77.
From Bonnell and Ford (1987).

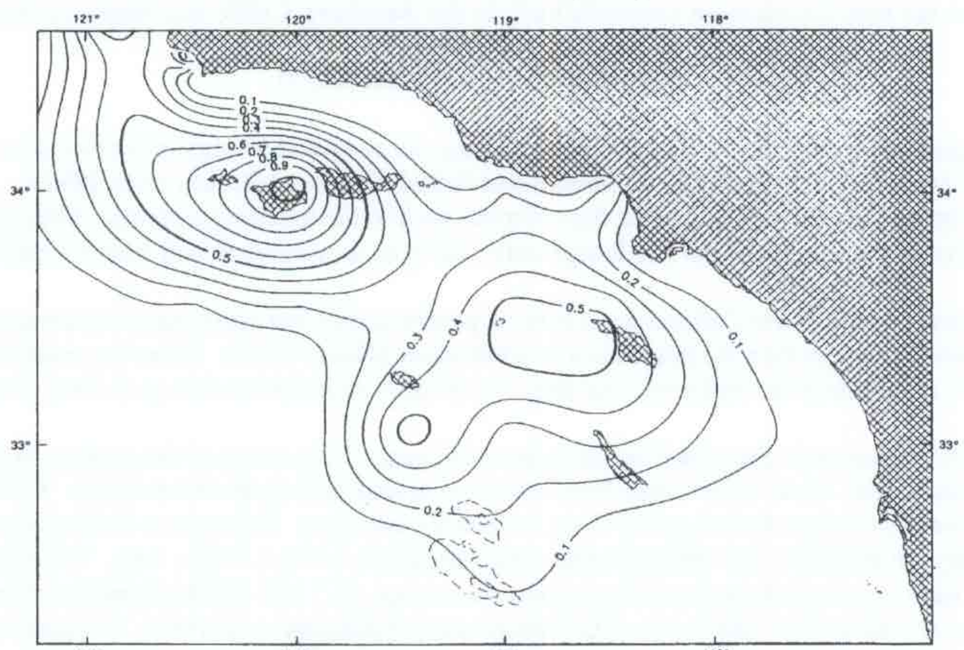


Figure 3.7-68
California sea lion distribution (animals/km^2) in the Southern California Bight during the dispersal from the rookeries (Sep-Nov), 1975-77.
From Bonnell and Ford (1987).

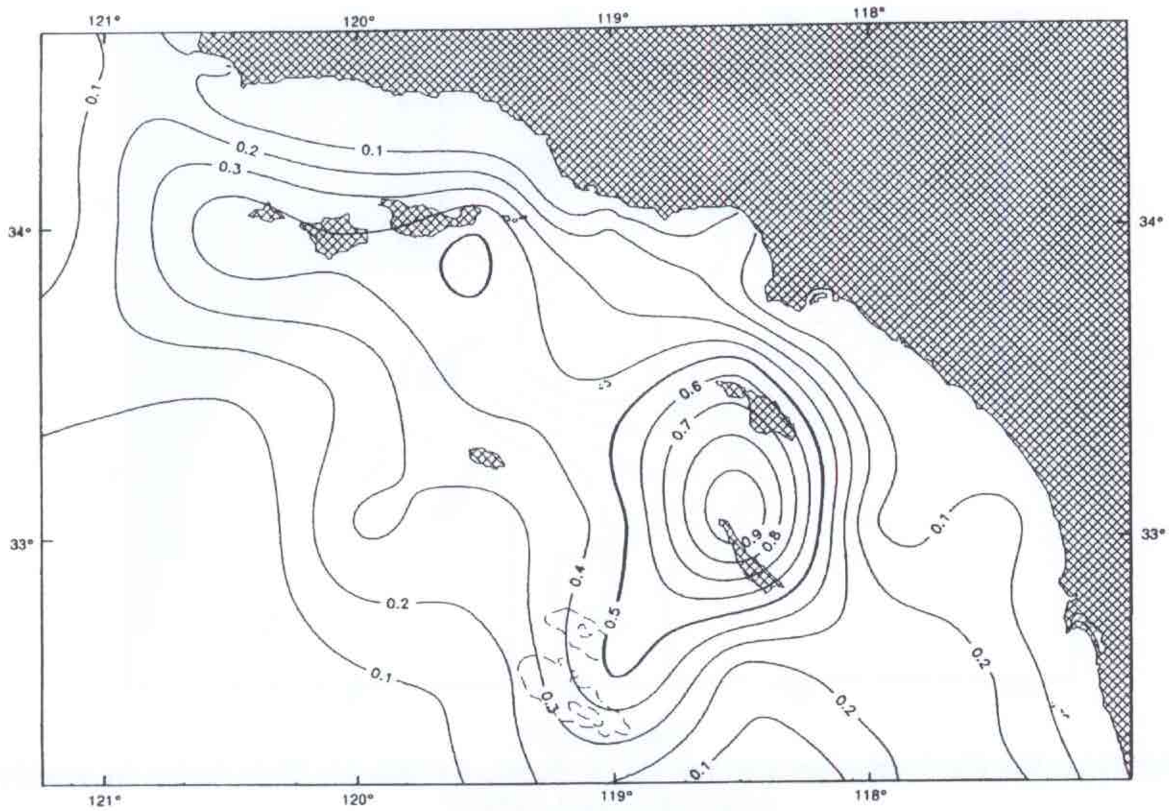


Figure 3.7-69
California sea lion distribution (animals/km^2) in the Southern California Bight during December to May, 1975-78.
From Bonnell and Ford (1987).

During August and September, after the mating season, the adult males migrate northward to feeding areas as far away as Washington (Puget Sound) and British Columbia (Lowry et al. 1992a). They remain there until spring (March to May), when they migrate back to the breeding colonies. Thus adult males are present in offshore areas of the Sea Range only briefly as they move to and from rookeries.

The distribution of immature California sea lions is poorly known but some make northward migrations that are shorter in length than the migrations of adult males (Huber 1991). However, most immatures are presumed to remain near the rookeries, and thus remain in or near the Sea Range (Lowry et al. 1992a).

Adult females remain near the rookeries throughout the year. They return to the rookery to give birth to their pups and breed. Most births occur from mid-June to mid-July (peak in late June). Females nurse their pups for about 8 days before going to sea to feed for two days. Subsequent feeding trips range from 1.7 to 3.9 days in duration, and subsequent nursing periods are 1.7 to 1.9 days long. The first feeding bouts after each departure from the rookery occur on average 16.7 NM (30.9 kilometers) from the rookery (range 0.81 to 55.9 NM [1.5 to 103.5 kilometers], Feldkamp et al. 1989). Females mate two to four weeks postpartum, usually in the water or at the water's edge. Weaning has been reported to occur at four to 8 months (Lowry et al. 1992a) and 10 to 12 months (Ono 1991), but there have been records of females nursing yearling pups. Pups begin to forage on their own when about 7 months old to supplement their mother's milk.

California sea lion populations have increased steadily since 1950 (Stewart et al. 1993). The entire population cannot be counted directly because different age and sex classes do not come ashore at the same time or places. Thus the size of the California sea lion population is estimated by

- counting pups late in the breeding season,
- multiplying pup counts by 1.15 to account for pup mortality between birth and the counting period, and
- multiplying the number of pups by 3.85 to 4.32 to account for other age and sex components of the population.

In 1995, 37,818 pups were counted in California waters. Based on the above procedure, the most recent estimate of the U.S. stock of California sea lions is 167,000-188,000 animals (Barlow et al. 1997). The specific counts for the various haul-out sites are not available. However, based on counts in earlier years, more than 95 percent or 159,000-179,000 animals would use haul-out sites and rookeries in the Sea Range. Based on the procedure described in Section 3.7.1.5, estimated totals of 45,227, 163,512, 72,276, and 133,414 California sea lions are present in the coastal and offshore waters of the Sea Range during winter, spring, summer, and autumn, respectively (Table 3.7-5).

This winter estimate is likely low. Although adult male California sea lions are feeding in areas north of the Sea Range, animals of all other ages and sexes spend most of their time feeding at sea during winter (Figure 3.7-53). Assuming that adult males are five percent of the Sea Range population (Heath and Francis 1984) and that 90 percent of the animals are at sea feeding at any time, approximately 136,000-153,000 California sea lions would be in coastal and offshore waters of the Sea Range during winter.

The estimate of 163,512 animals in the coastal and offshore waters of the Sea Range during spring is probably slightly high. Although the entire population of 157,000-179,000 is present in the Sea Range during this period, a high proportion of the adult males and adult females are hauled out at terrestrial sites during much of this period, and therefore, are not at sea (Figure 3.7-53).

The estimate of 72,276 animals in coastal and offshore waters during summer is reasonable. Adult male sea lions are returning north to feeding areas during this period. Adult females alternate between nursing and feeding at sea (August and October) and molting (September). Pups spend most of their time hauled out at rookeries but spend some time in the water nearby. Juveniles feed in offshore waters in the Sea Range.

The estimate of 133,414 in the Sea Range waters during autumn is also reasonable. The activities are similar to those in winter except that pups still spend considerable time hauled out at the rookeries.

Sea lions feed opportunistically on a wide variety of fish and cephalopods (Table 3.7-2). In the Sea Range the principal prey species were northern anchovy, Pacific whiting, and market squid. Sea lions also consumed juvenile rockfish, nail squid, and red octopus (Antonelis et al. 1990). At Santa Catalina Island, near the southeast corner of the Sea Range, the diet of 11 California sea lions consisted of 98 percent market squid (Lowry and Folk 1987). Farther north in San Diego County, the principal prey species were northern anchovy, white croaker, queenfish, and octopus (Lowry and Folk 1987). The diet probably changes during the year and between years as a result of changing oceanographic conditions. At San Clemente Island, south of the Sea Range, Lowry et al. (1990) found significant seasonal and interannual differences in diets. During years with El Niño influence, Pacific whiting (a major species in other years) almost disappeared from the diet and pelagic red crabs (almost absent in other years) became an important food type.

Information on movements and foraging at sea has been restricted to breeding females. (Adult males do not forage near the rookeries; they do not feed during the breeding season, and they migrate north after that season.) Over one third of the foraging dives by breeding females are one to two minutes in duration; 75 percent of dives are shorter than three minutes, and the longest dive was 9.9 minutes (Figure 3.7-70; Feldkamp et al. 1989). Approximately 45 percent of dives were to depths of 66 to 160 feet (20 to 50 meters) and the maximum depth of a dive was 900 feet (274 meters) (Figure 3.7-71; Feldkamp et al. 1989). Much of the variation in duration and depth of dives appears to be related to sea lions foraging on vertically-migrating prey. Longer dives to greater depths typically occur during the day and shorter dives to shallower depths typically occur at night (Figure 3.7-72; Feldkamp et al. 1989) as prey migrate toward the surface.

In summary, the California sea lion does not have a special status and its population has been increasing at 8.3 percent per year since 1983. It is the most commonly seen pinniped at sea in the Sea Range. More than 95 percent of the U.S. stock, or more than 159,000-179,000 animals, is associated with haul-out sites in the Point Mugu Sea Range, primarily on San Miguel and San Nicolas islands. Adult males haul out from mid-May to late July to defend territories and breed. After the breeding season they migrate north of the Sea Range to feeding areas as far north as Puget Sound and British Columbia where they remain until the following spring. Females give birth to their pups in mid-June to mid-July and breed three to four weeks later. They initially nurse their pups for 8 days and then alternate between feeding trips to sea of two to four days and nursing periods of about two days. Pups are usually weaned at about 8 months (range four to 12 months), but some are nursed for more than a year. Adult females and probably most subadults remain near the haul-out sites throughout the year and spend most of their time feeding at sea. Numbers appear to be lowest in offshore waters of the Sea Range (approximately 72,000) during summer when females are molting or nursing their pups, adult males are feeding north of the Sea Range, and pups are still nursing. Total numbers in offshore waters appear similar at other times of year (approximately 130,000 to 160,000), except at the peak of the breeding and pupping season in mid-June to early July when a large fraction of adult males and females is hauled out at rookeries. The principal prey species in the Point Mugu Sea Range are northern anchovy, Pacific whiting, and market squid. Most (75 percent) dives are less than three minutes in duration and to depths of 66 to 160 feet (20 to 50 meters), although dives of up to 10 minutes and 900 feet (274 meters) have been recorded. The longer and deeper dives tend to be during the day and the shorter and shallower dives during the night.

Steller Sea Lion, *Eumetopias jubatus*

The Steller sea lion is listed as **threatened** under the ESA and is currently being considered for **endangered** status as a result of 52 percent declines in counts in southwest Alaska from 1956-1960 to 1985 (Merrick et al. 1987). It is considered **depleted** under the MMPA. The Eastern stock, which occurs in California waters, is considered a **strategic stock** under the MMPA. The size of the Eastern stock (23,900 in 1994) has remained relatively stable since 1965 (19,300 in the 1960s, Barlow et al. 1997), but the size of the closest colony to the Sea Range, which is on Año Nuevo Island, has declined since 1970.

Steller sea lions range along the rim of the North Pacific Ocean from northern Japan to California (Loughlin et al. 1984). They are most common in the Gulf of Alaska and the Aleutian Islands. Formerly, San Miguel Island was the southernmost rookery. However, no adults have been sighted there since 1983, and no pups have been sighted there since 1981 (NMFS 1992). Currently, the southernmost breeding site is on Año Nuevo Island (37°06' north latitude), approximately 85 NM (157 kilometers) north of our study area. Steller sea lions are rarely sighted in the Point Mugu Sea Range and were not sighted during the surveys that were summarized to prepare this report (see Table 3.7-3).

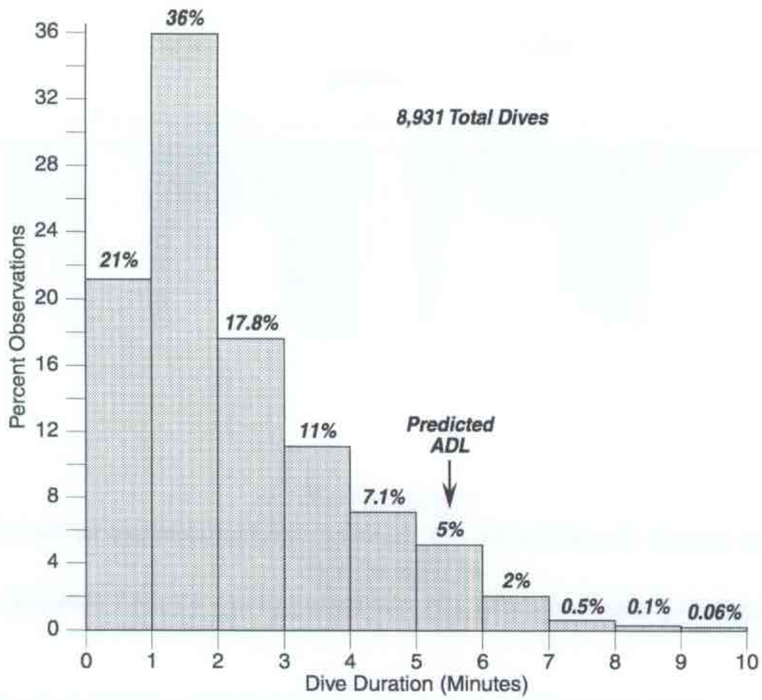


Figure 3.7-70
Percent observations of all recorded dive durations for adult female California sea lions. The predicted ADL of 5.8 min is shown by the arrow. Only 4% of dives exceeded this estimated limit. From Feldkamp et al. (1989).

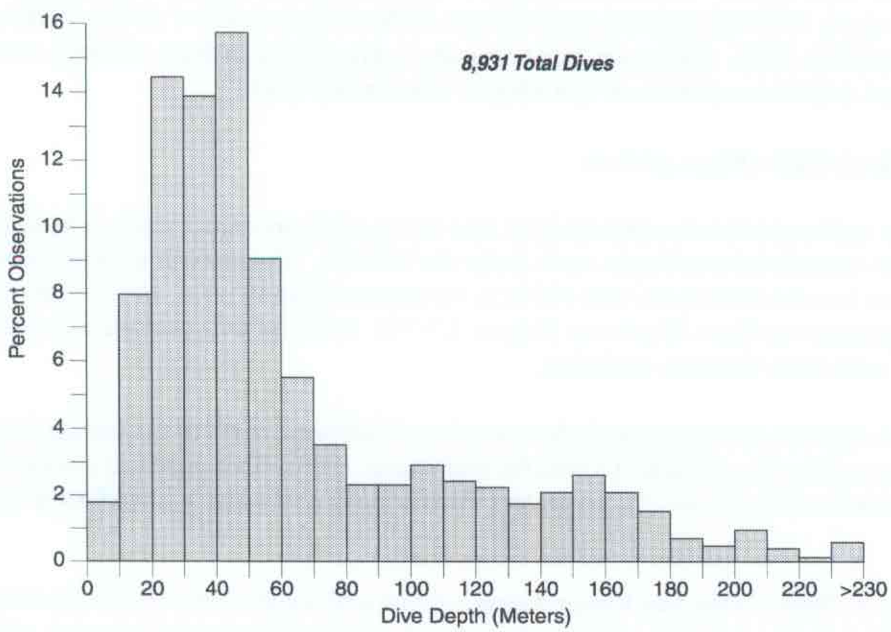


Figure 3.7-71
Percent observations of all recorded dive depths for adult female California sea lions. Less than 5% of dives were greater than 200 m in depth. From Feldkamp et al. (1989).

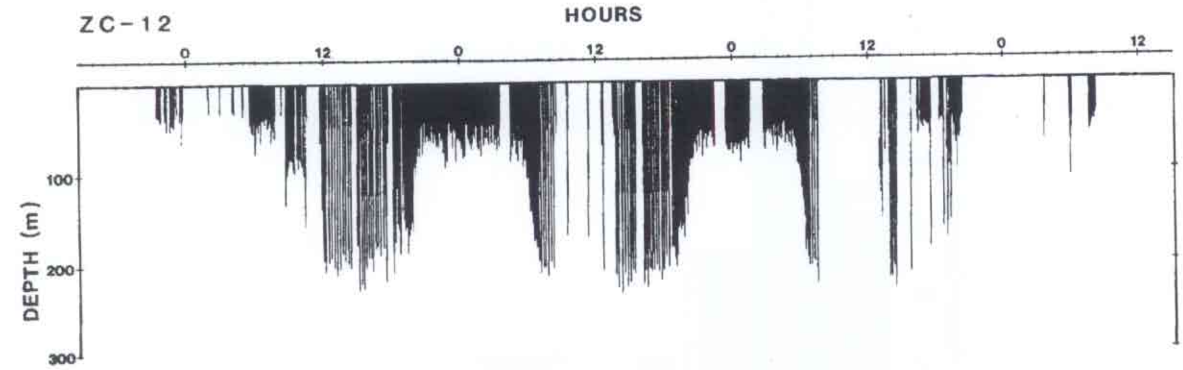


Figure 3.7-72
Segment of the diving record of sea lion ZC-12 showing vertical changes in dive depth as a function of time of day.
This pattern suggests pursuit of vertically migrating prey. From Feldkamp et al. (1989).

The number of Steller sea lions in California has declined from 6,000 to 7,000 in the late 1960s to about 2,000 in 1989 (Loughlin et al. 1992).

In summary, the Steller sea lion is **threatened** and perhaps endangered, and the stock occurring in California waters is considered a **strategic stock**. Stocks in southwestern Alaska have declined to about half of their 1956-1960 levels. The Eastern stock, which includes the California population, has remained stable since 1965 but colonies in California declined from 6,000 -7,000 in 1970 to approximately 2,000 in 1989. Steller sea lions now are rarely sighted in the Sea Range and no animals have been sighted at former colonies on San Miguel Island since 1983.

Northern Fur Seal, *Callorhinus ursinus*

The northern fur seal is not listed under the ESA and the San Miguel Island stock, which occurs in the Sea Range, is not considered a strategic stock under the MMPA. The number of pups born on San Miguel Island has increased from the mid 1960s to the present (Barlow et al. 1997). Since 1983, the annual rate of increase has been 25 percent (Figure 3.7-73). Much of this increase may have been due to immigration of seals from northern rookeries.

The range of the northern fur seal extends from southern California north to the Bering Sea, and west to the Okhotsk Sea and the Sea of Japan (Antonelis and Fiscus 1980). Two separate stocks of northern fur seals are recognized within US waters: an eastern Pacific stock and a San Miguel Island stock (Barlow et al. 1997).

Both stocks may be found in the Sea Range during autumn and winter, but only the San Miguel Island stock is found there during the May to November period. The San Miguel Island stock of northern fur seals probably remains in or near the Sea Range throughout the year, although some animals probably forage offshore of the Sea Range during the winter and spring. Most sightings during autumn and winter have been in offshore waters west of San Miguel Island (Bonnell et al. 1981; Bonnell et al. 1983), but few surveys have included areas farther offshore.

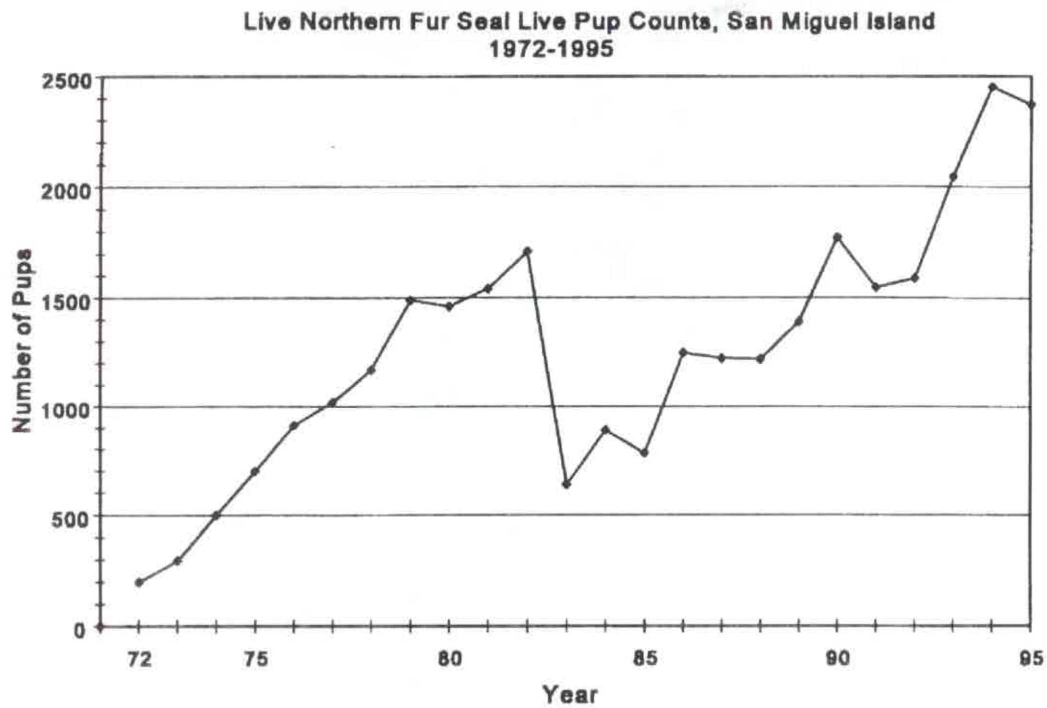


Figure 3.7-73
Counts of live northern fur seal pups on San Miguel Island, 1972-95.
From Barlow et al. (1997).

The eastern Pacific stock spends May to November in northern waters and at northern breeding colonies. In late November females and young begin to arrive in offshore waters of California, with some animals moving south into continental shelf and slope waters. Maximum numbers are found in waters from 34° to 42° north latitude during February to April; most are found offshore of the continental slope (Figures 3.7-74 and 3.7-75). By early June most seals of the eastern Pacific stock have migrated back to northern waters (Antonelis and Fiscus 1980).

Northern fur seals were extirpated from San Miguel Island during the mid-1800s by commercial sealing operations. After an absence of over 100 years they re-colonized the island during the late 1950s or early 1960s (DeLong 1982). The population at San Miguel Island has been increasing steadily since 1972, except for a drop in numbers during the El Niño event of 1982 (Figure 3.7-73; Barlow et al. 1997). The entire population cannot be counted directly because different age and sex classes do not come ashore at the same time or place. Thus the size of the northern fur seal population was estimated by

- counting pups and
- multiplying the number of pups by 4.0 to account for other age and sex components of the population and possible emigration of subadults.

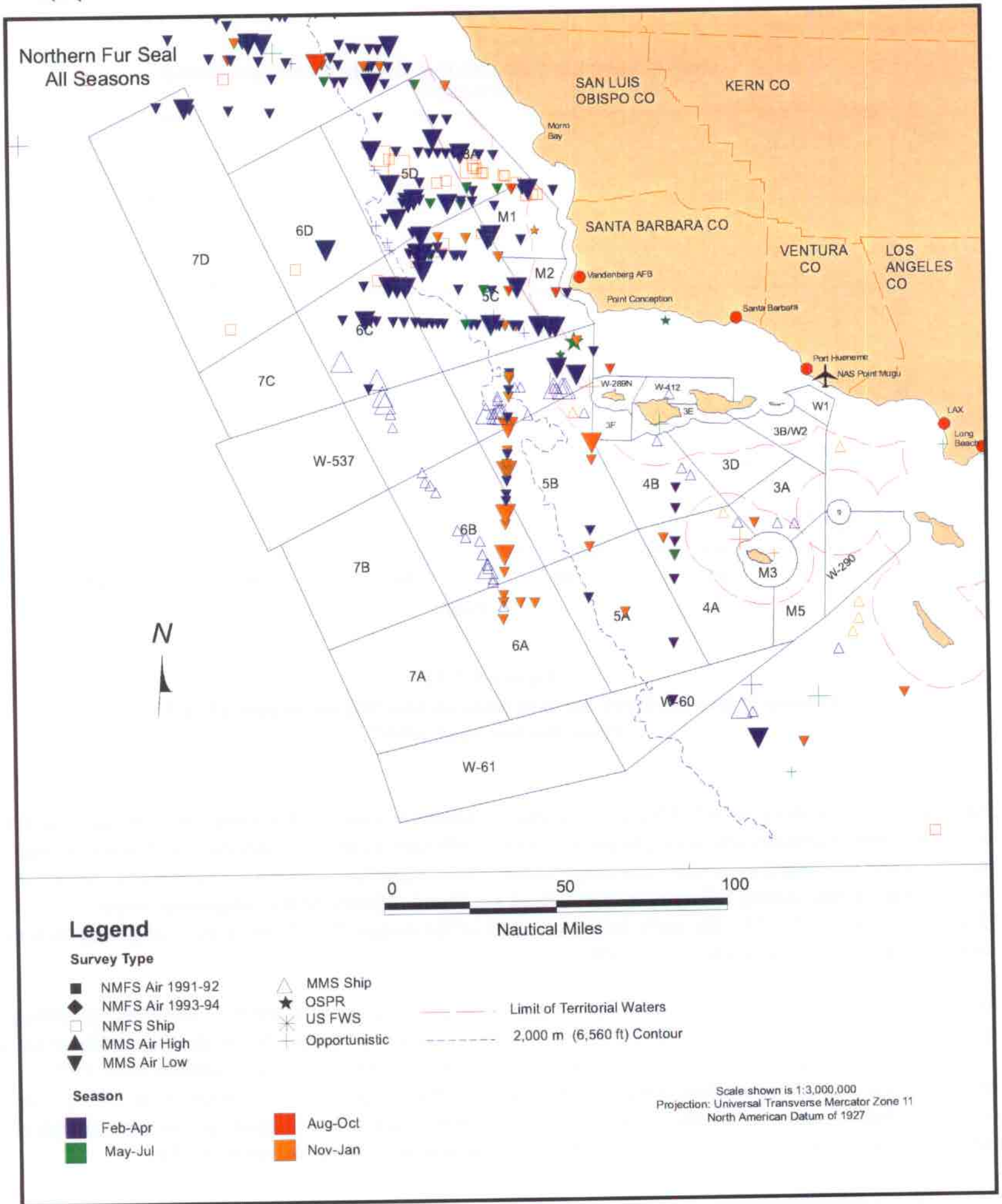


Figure 3.7-74

Sightings of northern fur seals during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

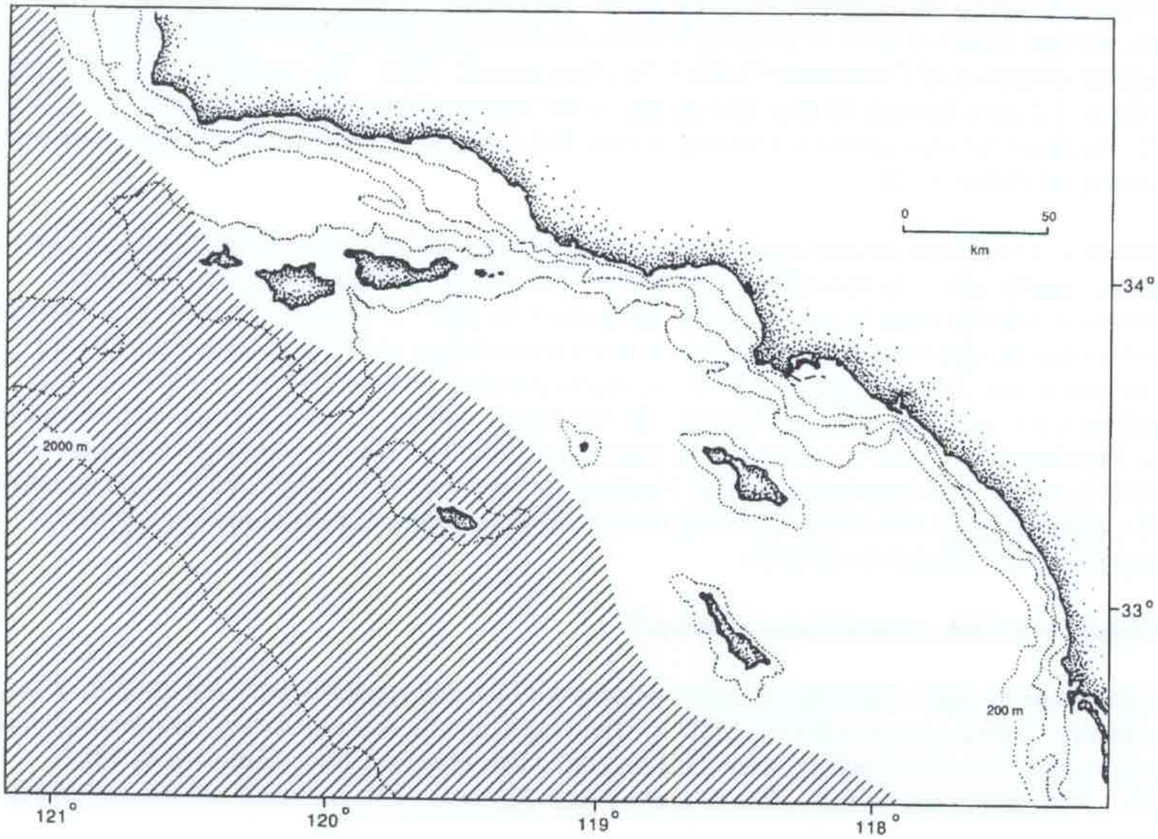


Figure 3.7-75
General distribution of northern fur seals during January through May in the Southern California Bight, 1975-78.
From Bonnell and Dailey (1993).

The most recent population estimate for the San Miguel Island stock, including seals that haul out at Castle Rock, is 10,036 (Barlow et al. 1997). The corresponding estimate for the eastern Pacific stock is 1,019,192 (Small and DeMaster 1995).

Northern fur seals found in the Sea Range during autumn and winter consist of animals from both stocks. Based on the procedure described in Section 3.7.1.5, estimated totals of 22,914 and 44,641 northern fur seals are present during autumn and winter, respectively, in coastal and offshore waters of the Sea Range (Table 3.7-5). During both seasons, about 98 percent of fur seals are found in non-territorial waters.

During spring, approximately 3,828 northern fur seals are present at sea within the Sea Range, with 99 percent being in non-territorial waters. During that period the remaining San Miguel Island northern fur seals are at haul-out sites where they are breeding and pupping. During summer, about 2,553 fur seals are present in non-territorial waters (Table 3.7-5). Adult males and most adult females are feeding in offshore waters, some apparently outside of the Sea Range. Most juveniles and pups are hauled out on San Miguel to nurse (pups) or to molt (juveniles).

A description of the behavior and activities of northern fur seals while they are hauled out on land is provided in Section 3.7.5.3 and is not repeated here. Although they feed primarily in deep offshore waters, average depths of dives of lactating females are relatively shallow (223 feet [68 meters]) with an average dive duration of 2.6 minutes (Table 3.7-2; Reeves et al. 1992). The durations of foraging trips increase by 1.2 days for each 30 days post partum as the season progresses (Loughlin et al. 1987; York 1987). Northern fur seals consume a variety of prey, but in the Sea Range they feed primarily on pelagic fish and squid (Table 3.7-2).

In summary, the northern fur seal does not have a special status and the San Miguel Island stock has increased steadily since recolonization in the late 1950s to about 10,000 animals now. This stock remains in or near the Point Mugu Sea Range throughout the year. In addition, some of the females and juveniles from the eastern Pacific stock migrate south into offshore waters of the Sea Range during autumn and winter. During autumn and winter, approximately 22,914 and 44,641 northern fur seals, respectively, are present in offshore waters of the Sea Range. When not hauled out on land, almost all (98 to 99 percent) are found in non-territorial waters *except during summer* when pups are commonly found in the water near their haul-out sites. Northern fur seals feed in the upper water layers (mean dive depth is approximately 225 feet [69 meters]) in deep offshore waters on pelagic fish and squid. An average dive is 2.6 minutes in duration.

Guadalupe Fur Seal, *Arctocephalus townsendi*

The Guadalupe fur seal is listed as **threatened** under the ESA and **depleted** under the MMPA. It is also considered a **strategic** stock under the MMPA. The Guadalupe fur seal population has increased at an average annual rate of 13.7 percent from 1954 to 1993 (Gallo-Reynoso 1994; Barlow et al. 1997; Figure 3.7-76) and it may be expanding its range (Gallo-Reynoso 1994; Le Boeuf and Bonnell 1980).

Archaeological evidence suggests that the Guadalupe fur seal was found in the Channel Islands before commercial exploitation reduced the population to near extinction (Walker and Craig 1979). It currently breeds only on Isla de Guadalupe in Mexico, about 250 NM (460 kilometers) south of the Sea Range (Le Boeuf and Bonnell 1980). Occasional sightings have been made in offshore waters in or near the Sea Range as well as on the Channel Islands. Between 1969 and 1986, 43 sightings of Guadalupe fur seals were made at San Miguel and San Nicolas islands, including one territorial male that was seen each year from 1981 to 1986. This species has also been sighted at Santa Barbara Island (two sightings) and San Clemente Island (one sighting, Stewart et al. 1987). Previous to 1985, there were only two recent sightings of Guadalupe fur seals from central and northern California (Monterey Bay in 1977 and Princeton Harbor in 1984, Weber and Roletto 1987). However, nine strandings and five sightings were reported along the central and northern coast of California from 1988 to 1995, suggesting that the Guadalupe fur seal may be expanding its range (Hanni et al. 1997).

The most recent population estimate was 7,408 in 1993 (Gallo-Reynoso 1994; Barlow et al. 1997). Very few of these animals are expected to occur within the Sea Range.

There is little information on feeding habits of the Guadalupe fur seal, but it is likely that they feed on deep-water cephalopods and small schooling fish like their relative the northern fur seal (Seagars 1984). Digestive tracts of stranded animals in central and northern California contained primarily squid (*Loligo opalescens* and *Onychoteuthis borealojaponica*) with a few otoliths of lampfish (*Lampanyctus*) and Pacific sanddab (*Citharichthys sordidus*) (Hanni et al. 1997). Near Isla de Guadalupe a single female that was monitored using a time depth recorder (TDR) appeared to feed primarily near the surface (modal depth 10.2 feet [3.1 meters] and mean depth 55 feet [16.9 meters], Gallo-Reynoso 1994).

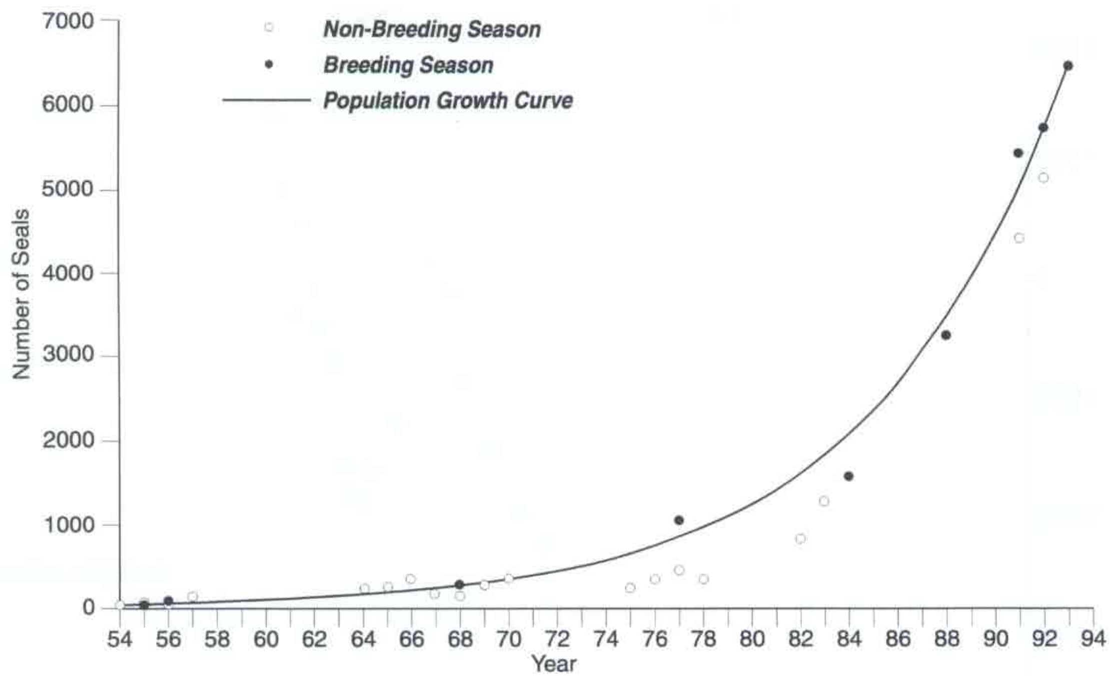


Figure 3.7-76
Counts of Guadalupe fur seals at Guadalupe Island, Mexico, and the estimated population growth curve derived from counts made during the breeding season.
From Barlow et al. (1997).

In summary, the Guadalupe fur seal is **threatened** and **depleted**; the only remaining stock is considered a **strategic stock**. This species has been seen occasionally in the Sea Range (46 sightings from 1969 to 1986), but the entire population (7,400 animals) is centered on Isla de Guadalupe, Mexico, approximately 250 NM (463 kilometers) south of the Sea Range. The population has been growing at 13.7 percent per year since 1954, and may be expanding its range. Little is known about its foraging behavior and food preferences but squid is likely an important part of its diet.

3.7.2.4 Sea Otter

The southern sea otter (*Enhydra lutris nereis*) is listed as **threatened** under the ESA and **depleted** under the MMPA. It is also considered a **strategic** stock under the MMPA. The southern population has increased at an average annual rate of 5 to 7 percent. As the population has increased, its range has also expanded. The sea otter is managed by the U.S. Fish and Wildlife Service. (All other species of marine mammals occurring within the Sea Range are managed by the National Marine Fisheries Service.)

The sea otter occupied a historic range throughout the northern Pacific Coastal region, from Russia and Alaska to Mexico (Kenyon 1969), but harvests of sea otters in the 18th and 19th centuries nearly exterminated the species (Orr and Helm 1989). In recent years, the northern population has increased to well over 100,000 individuals, while the southern or California population has grown more slowly, apparently due to a lower rate of pup survival (Riedman et al. 1994). Except during the 1976 to 1983 period, the southern population has increased steadily since it received protection in 1911 (Figure 3.7-77).

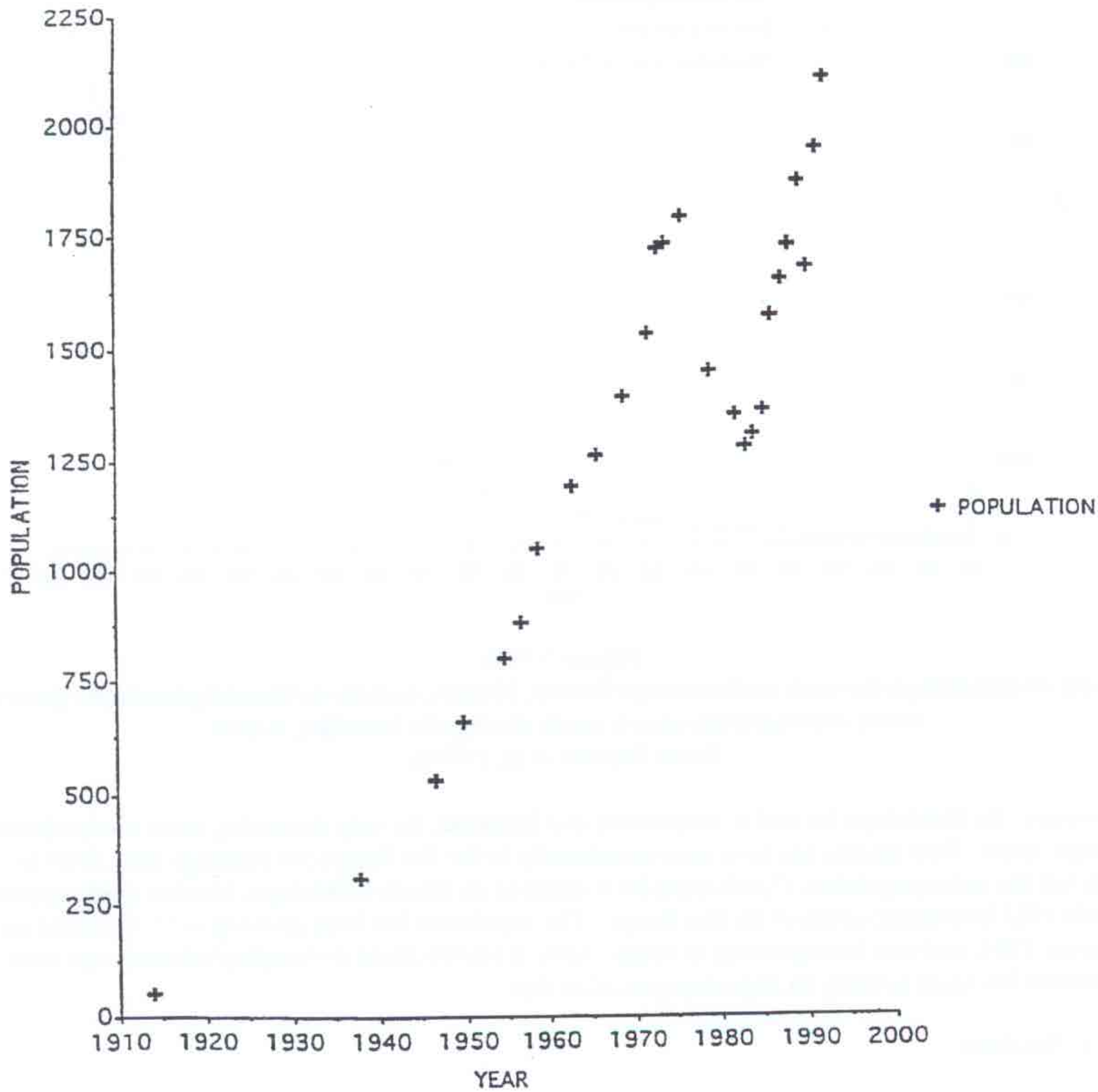


Figure 3.7-77
Trends in the California sea otter population, 1914-92.
From USFWS (1996).

The southern sea otter's primary range is restricted to the coastal area of central California, from Point Año Nuevo to Purisima Point (Orr and Helm 1989; USFWS 1996), plus a small translocated population around San Nicolas Island. Thus sea otters are rarely sighted in the Point Mugu Sea Range other than immediately around San Nicolas Island. During the aerial and ship surveys summarized for this report (see Table 3.7-3), there were only three sightings of them in the Sea Range and one additional sighting near Point Mugu. However, they were commonly sighted along the coast east of the northern part of the Sea Range (Figure 3.7-78). Sea otters are expanding southward along the coast, including a recent expansion south of Point Conception into the Santa Barbara area.

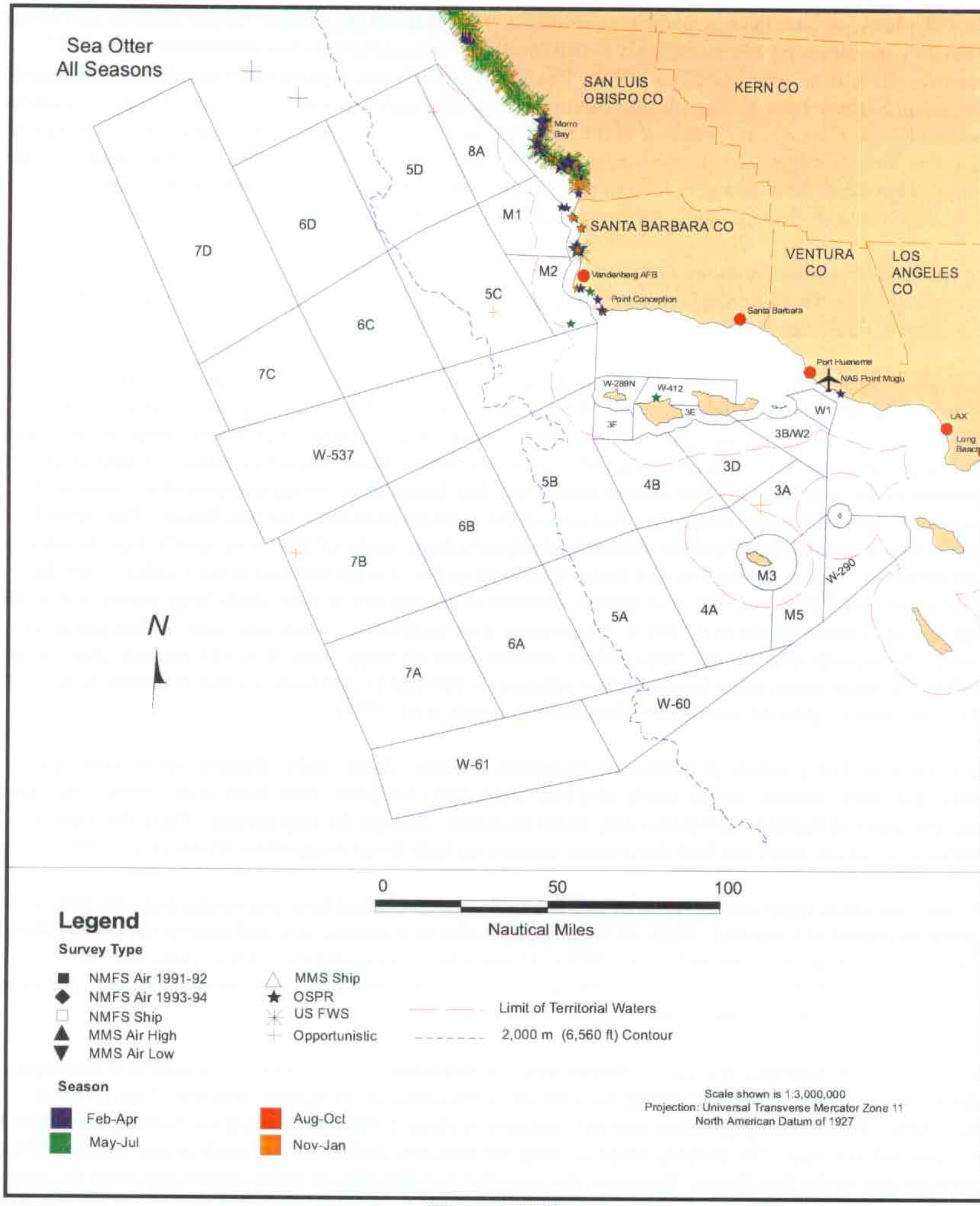


Figure 3.7-78

Sightings of sea otters during the 1975-96 surveys listed in Table 3.7-3. Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively.

In 1987-1990, an attempt was made to establish an "experimental population" of sea otters at San Nicolas Island by translocating 139 individuals to that location. This population has diminished to about 17 animals (Ralls et al. 1996; USFWS 1996). The San Nicolas Island experimental population is discussed further in Section 3.7.4.4. The translocation plan included establishment of a "no otter" zone elsewhere south of Point Conception. Because of the potential for sea otters to affect shell fisheries, it was agreed that sea otters found in the "no otter" zone would be captured and moved to San Nicolas Island or to the main range along the central California coast (Ladd 1986). However, the sea otter population has now expanded south from the central California coast into the "no otter" zone.

In spring 1995, the southern sea otter population was estimated to number 2,377 (USFWS 1996). At present, the San Nicolas Island sea otter population (about 17 animals, including pups) cannot be considered viable because the population size is too small (USFWS 1996).

Sea otters prefer rocky shorelines with kelp beds and waters about 66 feet (20 meters) deep (USFWS 1996). Few sea otters venture beyond 5,249 feet (1,600 meters) from shore and most remain within 1,640 feet (500 meters) (Estes and Jameson 1988). Aside from the small translocated population at San Nicolas Island, few sea otters are expected to occur within the Point Mugu Sea Range because of their preference for relatively shallow coastal waters (the Sea Range does not include any of the mainland coastline); most are found along the coast east of the northern portion of the Sea Range. They spend most of their time in the nearshore waters, and require a high intake of protein to satisfy their metabolic requirements. Most sea otters in California tend to be active at night and rest in the middle of the day (Ralls and Siniff 1990). There is extensive variation in the activity of individuals both among and within age and sex classes (Ralls et al. 1995). Their mean dive duration is 74 seconds, with the longest dives being 246 seconds (Ralls et al. 1995). Mean surface intervals range from 26 to 155 seconds (Ralls et al. 1995). Juvenile males often forage farther offshore (4,200 feet [1,280 meters]) and in deeper waters (100 feet [30 meters]) than do juvenile or adult females (Ralls et al. 1995).

Sea otters feed on a variety of benthic invertebrates: mussels, clams, crabs, abalone, sea urchins, sea stars, tunicates, octopus, turban snails, and kelp crabs (Orr and Helm 1989; Ralls et al. 1995). They are key predators of benthic species that can, when abundant, damage the kelp forests. Thus, the historic elimination of sea otters has had detrimental impacts on kelp forest ecosystems (Estes et al. 1989).

Female sea otters attain sexual maturity at three to five years old and bear one young annually after a gestation period of 6 months. Pups are weaned when five to 6 months old, and depend on their mothers for some time after this (Orr and Helm 1989). Males attain sexual maturity at five years old. In California, most births occur from late February to early April, but births may occur throughout the year (Siniff and Ralls 1991; Jameson and Johnson 1993).

In summary, the southern sea otter is **threatened** and **depleted** and this stock is considered a **strategic stock**. It was nearly extirpated during the 18th and 19th centuries by hunters who killed sea otters for their pelts. The present population size in California is about 2,400 animals and has been increasing at 5 to 7 percent per year. The primary range is along the central California coast north of and inshore of the northern part of the Sea Range. However, the sea otter is expanding its range southward along the coast. In addition, in 1987-1990 an attempt was made to establish an "experimental population" at San Nicolas Island; this population has diminished to about 17 animals. Sea otters prefer rocky shorelines and water about 66 feet (20 meters) deep. They feed on benthic invertebrates, including mussels, clams, crabs, abalone, sea urchins, and sea stars. Their predation on the latter species may help to maintain the kelp forests. Sea otters are very rarely seen in offshore areas in the Sea Range.

3.7.3 NAS Point Mugu

Many of the species of marine mammals occurring in the Sea Range tend to occur in deep waters, and are expected to be rare in or absent from nearshore waters within 3 NM (5.6 kilometers) of Naval Air Station (NAS) Point Mugu (see Section 3.7.2). In fact, only five species of cetaceans, one species of pinniped, and the sea otter were seen within 3 NM (5.6 kilometers) of Point Mugu during the studies that are summarized here (see Table 3.7-3). However, there has been only a very limited amount of survey coverage in nearshore waters off Point Mugu. On rare occasions, other species might be encountered in these waters.

3.7.3.1 Odontocetes (Toothed Whales)

Only four species of odontocetes were sighted within 3 NM (5.6 kilometers) of shore in the vicinity of Point Mugu. They were Dall's porpoise, bottlenose dolphin, common dolphin, and pilot whale.

Dall's Porpoise

Dall's porpoises are normally found well offshore except in locations where deep canyons approach the coast, as occurs at Point Mugu. These nearshore sightings are most often made in winter. In November of 1975, one pod of four Dall's porpoises was sighted near the coast east southeast of Point Mugu (Figure 3.7-12). In general, however, Dall's porpoises are rare close to shore near Point Mugu (Figures 3.7-9 to 3.7-12).

Bottlenose Dolphin

The coastal stock of bottlenose dolphins might be expected to be found in nearshore waters near Point Mugu because they are commonly seen along the coast 80 to 100 NM (148 to 185 kilometers) southeast of there and are occasionally seen along the coast northwest of there (Figure 3.7-24). However, only two sightings were made near Point Mugu during the studies summarized on Figure 3.7-24. Both sightings involved groups of 10 dolphins - one group seen during August and the other during December.

Common Dolphin

Common dolphins are abundant throughout offshore areas of the Sea Range, but there was only one sighting of 20 animals in nearshore waters near Point Mugu during the studies summarized in Figures 3.7-26 to 3.7-29. This sighting was during spring (May).

Pilot Whale

Within the general study region, the pilot whale was found mainly south and east of Point Mugu during the years when the species was common in the area (i.e., prior to 1983). However, four sightings were made near Point Mugu during the studies summarized here (Figure 3.7-36). They were all seen during October to December, and all involved groups of about 20 whales. Pilot whales have been rare in the SCB in recent years.

3.7.3.2 Mysticetes (Baleen Whales)

The only mysticete occurring in nearshore waters adjacent to Point Mugu is the gray whale.

Gray Whale

A significant proportion of the 23,100 gray whales in the California stock migrate through or near the nearshore waters adjacent to Point Mugu during their autumn-winter migration southward and during their winter-spring migration northward (Figures 3.7-45 and 3.7-42). The numbers passing Point Mugu at various distances from shore have not been specifically documented. The onshore-offshore distribution is likely to differ from that at some other locations where it has been studied, as gray whales migrating through the SCB follow several migration corridors and do not all travel close to the mainland shoreline (Figure 3.7-46).

The occurrence of gray whales in nearshore waters near Point Mugu is strongly seasonal. Significant numbers are present only during late autumn to winter (December to April). The peak of southbound migration is in early-to-mid January and the peak of northbound migration is in March. Mothers and calves tend to migrate later in the spring than do other whales. Mothers and calves, which may be the most sensitive component of the population to disturbance, tend to use offshore migration routes; and therefore, most do not pass close to NAS Point Mugu. On the other hand, movements of mothers and calves tend to be more leisurely, so that any mother/calf pairs occurring near NAS Point Mugu are likely to remain there longer than would other gray whales.

3.7.3.3 Pinnipeds

The only pinniped that is seen in large numbers near Point Mugu is the harbor seal, which hauls out at the entrance to Mugu Lagoon. Small numbers of California sea lions feed and haul out near NAS Point Mugu, but northern elephant seals and northern fur seals are seldom seen there.

Harbor Seal

The general biology and status of harbor seals are described in Section 3.7.2.3 and that material is not repeated here.

The harbor seal is a year-round resident at the entrance to Mugu Lagoon. Like coastal haul-out populations farther north, the colony at Mugu Lagoon entrance appears to be steadily increasing in numbers. In the early-to-mid 1980s, less than 100 harbor seals were counted there during the molting period (May and June; Figure 3.7-79). From 1988 to 1995, from 120 to 243 seals were counted in June during the index counts conducted by D. Hanan (1996; personal communication). Aerial counts of this type underestimate total numbers using the area, as animals at sea during the time of the count are not recorded.

Since early April 1992, Navy scientists have conducted year-round counts of harbor seals hauled out at NAS Point Mugu. The peak counts have been slightly higher than the index counts reported by Hanan (1996) (Figure 3.7-79). This is to be expected given that the Navy counts are repeated frequently whereas Hanan's counts are done once per year. However, even the Navy counts probably do not include all of the seals using the site because:

- some individual seals may haul out primarily at night and feed at sea during the day, when most other seals are hauled out (see Stewart and Yochem 1994),
- counts are conducted only once, or occasionally twice, a day and higher numbers may be present at other times, and

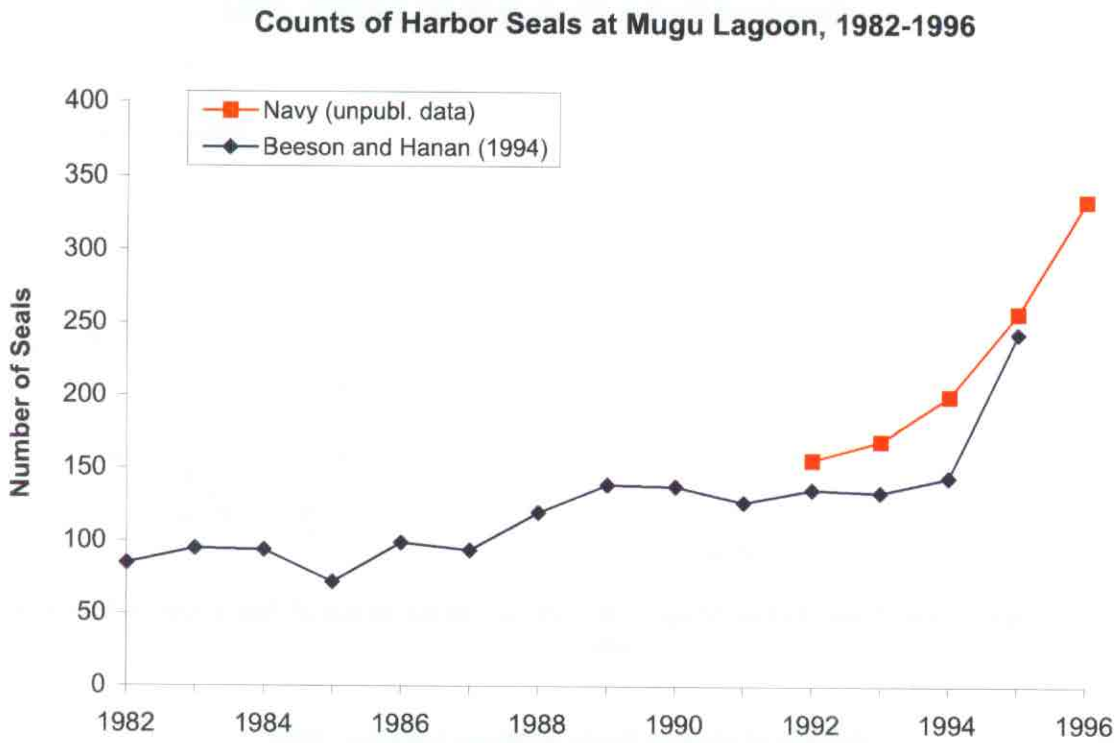
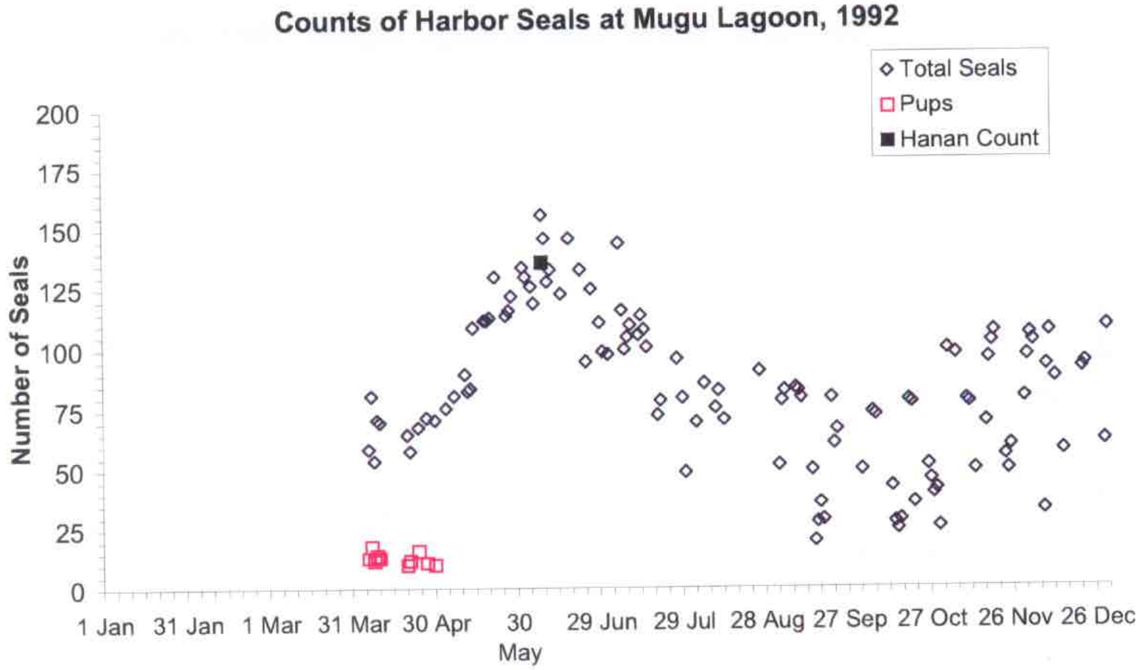


Figure 3.7-79
Counts of harbor seals at Mugu Lagoon, 1982-96.
Aerial counts are from Beeson and Hanan (1994) and Hanan (personal communication).
Ground counts are from peak counts obtained by the U.S. Navy in each year (see Figure 3.7-80).

- the timing of the molt, and hence the period of peak haul out, is different for different age and sex groups so that some segments of the population may be underrepresented in virtually all counts.

Surprisingly high numbers of seals were hauled out at NAS Point Mugu on most days with Navy counts during August to February (Figure 3.7-80). Other studies have suggested that harbor seals spend most of their time foraging at that time of year, and that they may spend up to a week away from their haul-out site. It is possible that abundant food resources near the NAS Point Mugu haul-out site permit harbor seals to spend more time hauled out there than at other sites where food may be less abundant.

The peak number of harbor seals hauled out at NAS Point Mugu during 1996 was 334 adults (13 June) and the population appears to be increasing (Figure 3.7-80). This represents about 1.4 percent of the entire California population and about 8 percent of the harbor seals found south of 35° north latitude. From July to April as many as 150 to 250 seals may be hauled out each day although there is a great deal of day-to-day variation. NAS Point Mugu is not a major pupping area; 25 to 30 pups are born there annually (T. Keeney, Point Mugu Environmental Division, personal communication 1998).



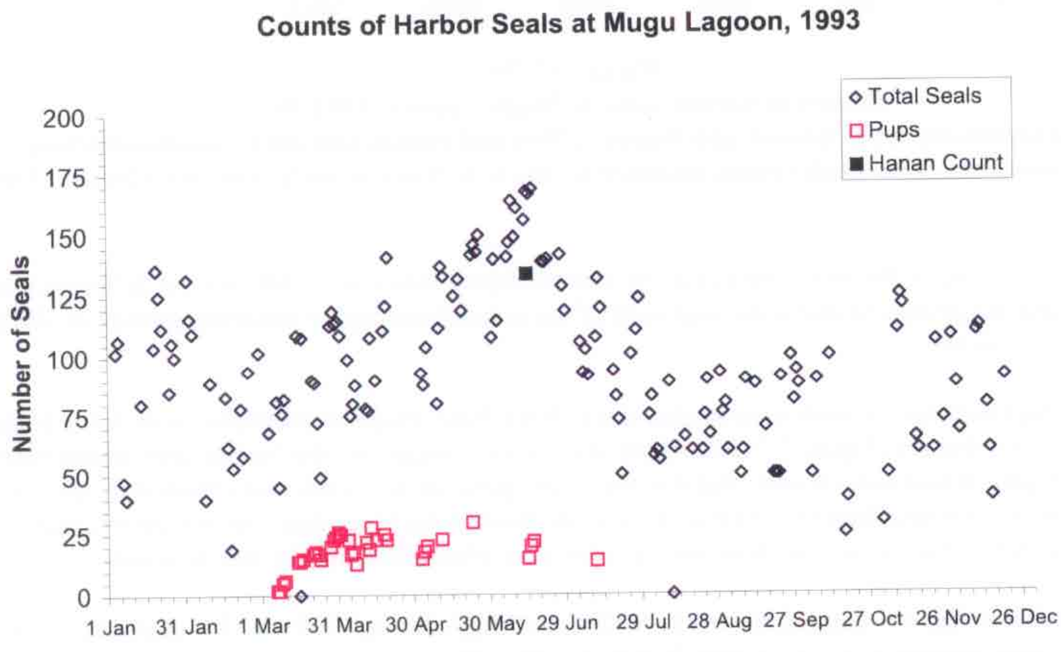
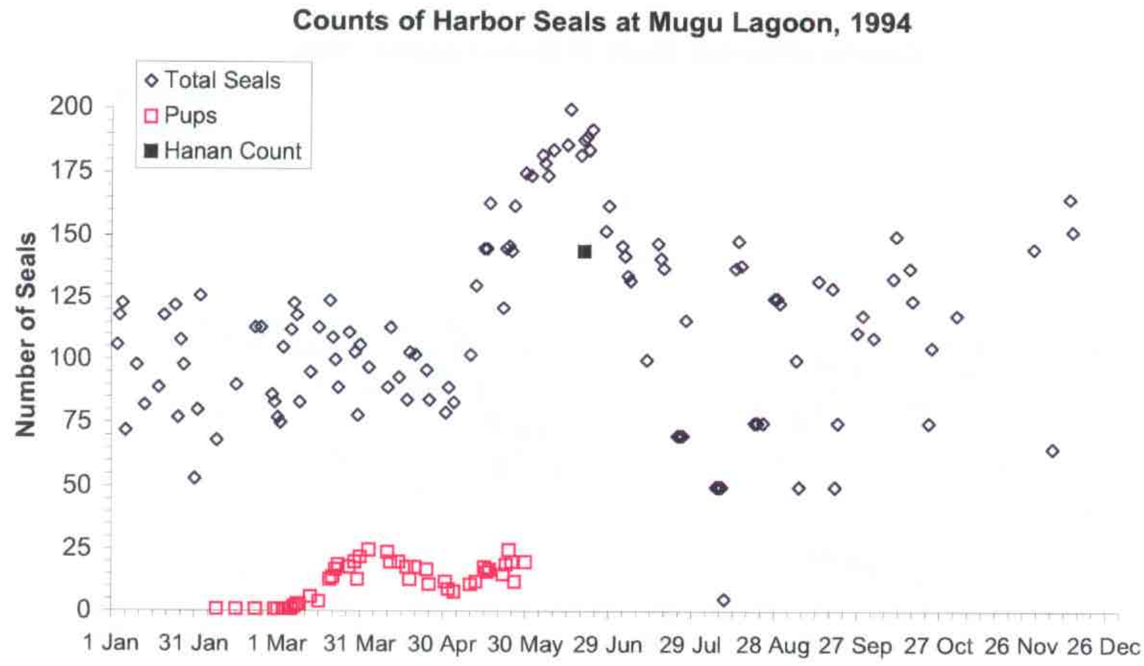


Figure 3.7-80
Counts of harbor seals at Mugu Lagoon by the U.S. Navy (unpublished data), 1992-96. Aerial Index Counts and their dates were provided by Hanan (personal communication).



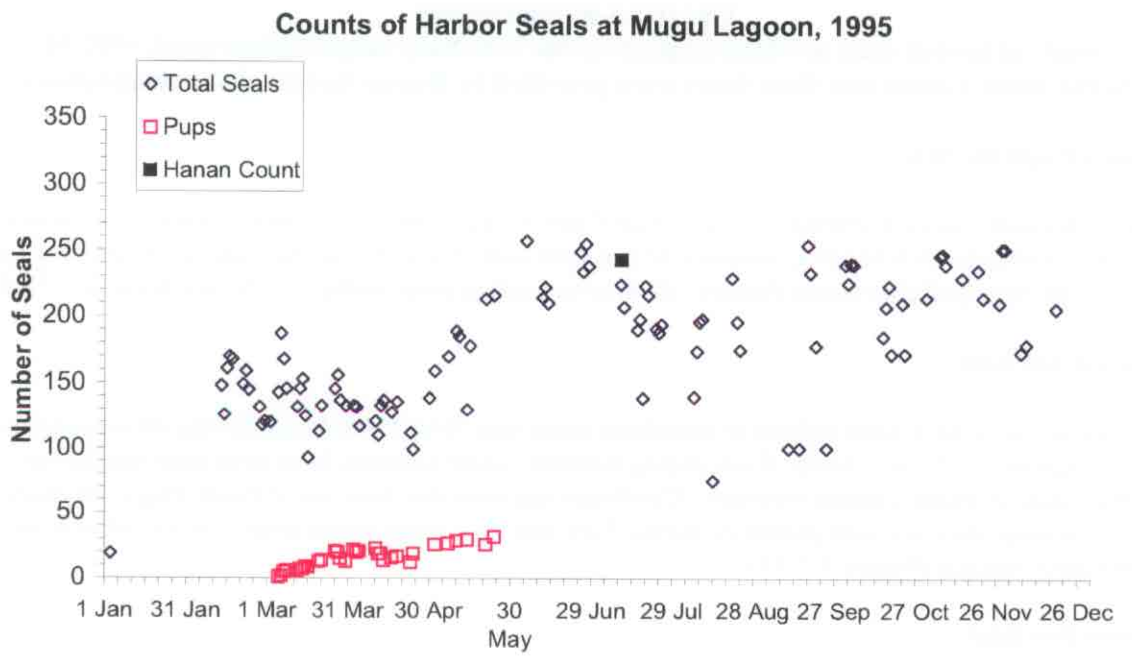


Figure 3.7-80 (continued)
Counts of harbor seals at Mugu Lagoon by the U.S. Navy (unpublished data), 1992-96. Aerial Index Counts and their dates were provided by Hanan (personal communication).

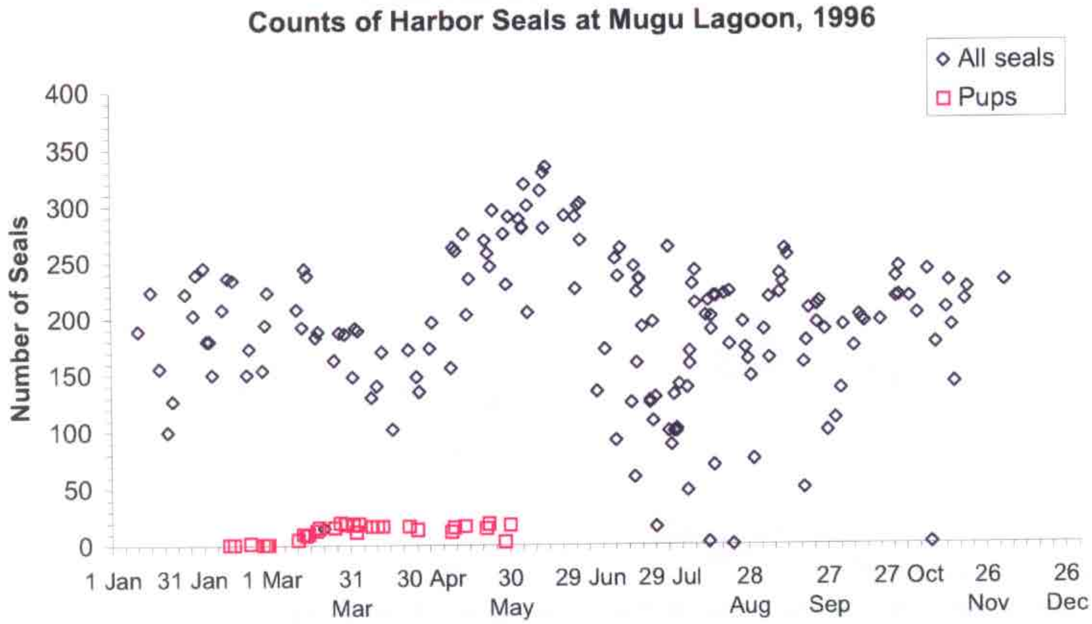


Figure 3.7-80 (continued)
Counts of harbor seals at Mugu Lagoon by the U.S. Navy (unpublished data), 1992-96. Aerial Index Counts and their dates were provided by Hanan (personal communication).

Northern Elephant Seal

Northern elephant seals are unlikely to occur near Point Mugu. The nearest haul-out site is on Anacapa Island approximately 10 NM (19 kilometers) to the west and only a few animals use it. When they leave haul-out sites, they probably travel directly offshore to feeding areas farther north (see Section 3.7.2.3).

California Sea Lion

California sea lions have been sighted in nearshore areas near NAS Point Mugu during all seasons except summer (Figures 3.7-63 to 3.7-66). Even during summer, small numbers have been seen hauled out near the harbor seals at Mugu Lagoon entrance. California sea lions that haul out at Point Mugu are probably subadults because they are seen primarily during June and July when adults tend to be found at or near their breeding beaches (Figure 3.7-53).

Northern Fur Seal

Northern fur seals are unlikely to occur in the immediate vicinity of NAS Point Mugu as their distribution during the winter and spring, when they are most abundant in the general area, is offshore (Figure 3.7-74).

3.7.3.4 Sea Otter

There was one sighting of a sea otter along the coast south of NAS Point Mugu during winter (February), and the carcass of an adult male was found at Point Mugu on 24 April 1998 (G. Smith, Point Mugu Environmental Division, personal communication 1998). South of Point Conception, sea otters are rare but expanding southward along the coast (see Section 3.7.2.4).

3.7.4 San Nicolas Island

Only a few species of cetaceans are known to occur in waters near San Nicolas Island, and then only in small numbers. However, San Nicolas Island and adjacent waters are important for northern elephant seals, California sea lions, and harbor seals. The Guadalupe fur seal has been seen here in recent years. San Nicolas Island is also the location to which southern sea otters have been translocated in an attempt to establish a population separate from that in central California.

3.7.4.1 Odontocetes (Toothed Whales)

Two species of odontocetes (Dall's porpoise and northern right whale dolphin) were recorded in waters within 3 NM (5.6 kilometers) of San Nicolas Island during the studies summarized here. Three other species, the common dolphin, pilot whale, and Risso's dolphin, were seen in Range Area M3 (the Range Area surrounding San Nicolas Island, see Figure 3.7-1). However, they were sighted more than 3 NM (5.6 kilometers) from the coast. There are two records of Cuvier's beaked whales stranded on San Nicolas Island (Leatherwood et al. 1987; G. Smith, Point Mugu Environmental Division, personal communication 1998), but at least the first of those animals probably drifted there after it died at sea. As is true for any small region of the study area, the amount of survey coverage of nearshore waters near San Nicolas Island has been low. Other species of odontocetes may occasionally occur in these waters in small numbers.

Dall's Porpoise

Dall's porpoise is one of the most abundant cetacean species in the continental slope and offshore regions of the Sea Range (see Section 3.7.2.1), but it is not common near land. Only one sighting of Dall's porpoise was made within 3 NM (5.6 kilometers) of the south shore of San Nicolas Island during the studies summarized here (Figure 3.7-81). This sighting was of a group of two animals during January. A second sighting was made within Range Area M3 during January but that sighting was farther than 3 NM (5.6 kilometers) from shore.

Northern Right Whale Dolphin

Northern right whale dolphins are common in continental slope and offshore waters of the Sea Range during winter and spring. However, only one group was sighted within 3 NM (5.6 kilometers) of San Nicolas Island during the studies that are summarized here (Figures 3.7-31 to 3.7-34). It was a group of 20 animals sighted northeast of the island during January of 1977. Two additional groups were sighted more than 3 NM (5.6 kilometers) from shore south of San Nicolas Island during February-April.

3.7.4.2 Mysticetes (Baleen Whales)

Two species of mysticetes, gray and humpback whales, have been recorded within 3 NM (5.6 kilometers) of San Nicolas Island. Two other species, fin and minke whales, were recorded in Range Area M3 but

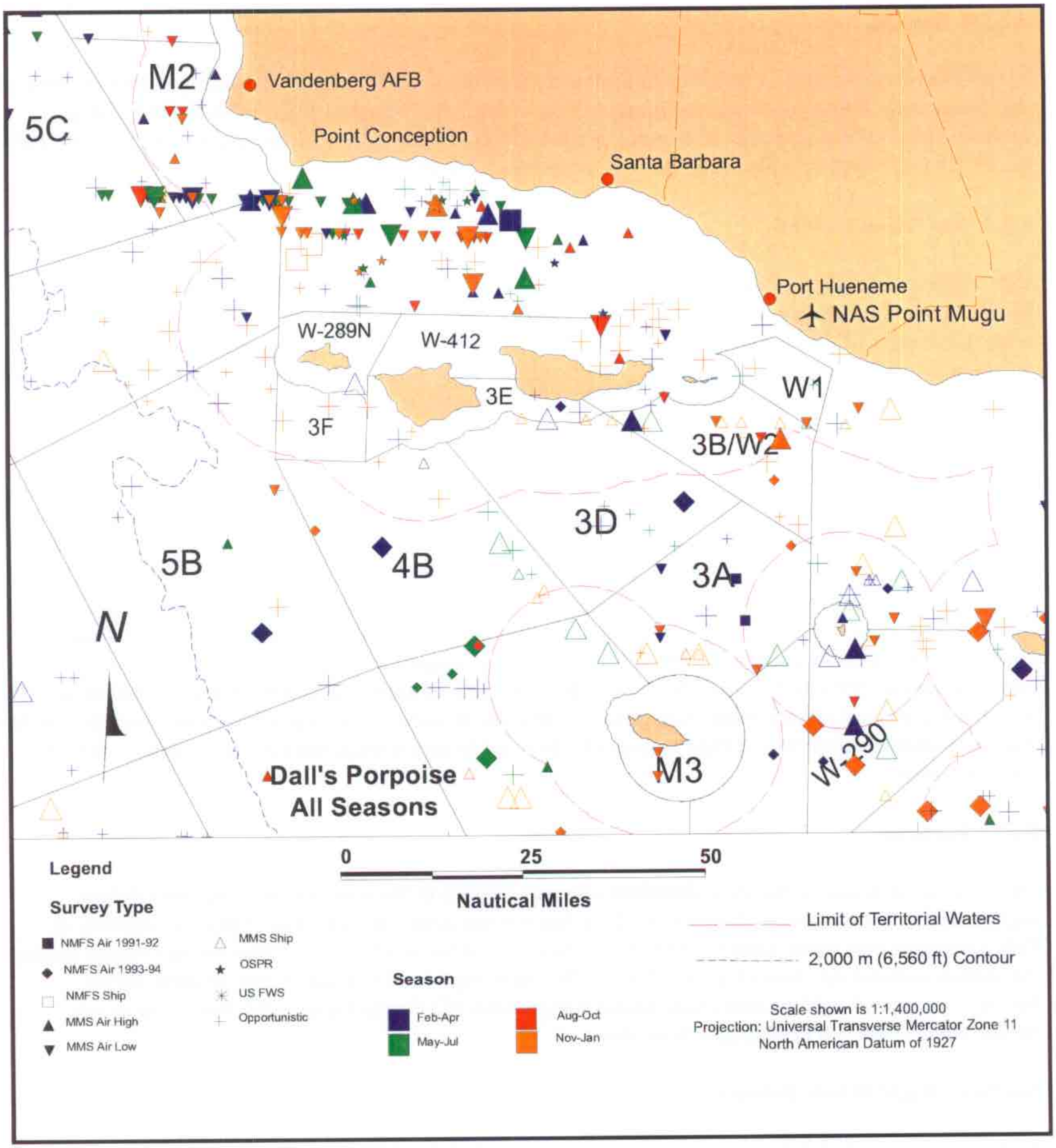


Figure 3.7-81
Sightings of Dall's porpoises in and near the Channel Islands during the 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of 1-4 vs. 5 or more animals, respectively.

were farther than 3 NM (5.6 kilometers) from the coast of San Nicolas Island. Blue whales are common just west of San Nicolas Island, and there is one stranding record on the island.

Humpback Whale

No humpback whales were sighted within 3 NM (5.6 kilometers) of San Nicolas Island during the studies summarized here (Figure 3.7-48). However, Leatherwood et al. (1984) reported a single animal near the kelp beds off the south shore of San Nicolas Island during July 1984.

Gray Whale

The most offshore of the known migration corridors of gray whales through the SCB passes near San Nicolas Island (Figures 3.7-42, 3.7-45, 3.7-46). Most sightings of gray whales near the island are during late autumn and winter when the peak of the southbound migration (early-to-mid January) and the peak of the northbound migration (March) occur. There were two late autumn sightings less than 3 NM (5.6 kilometers) from shore during the summarized studies, plus two additional late autumn sightings just beyond 3 NM (5.6 kilometers) offshore (Figure 3.7-82). There was also a spring (July) sighting of four gray whales just off the east coast of the island; these whales seen outside the migration seasons may have remained near San Nicolas Island for an extended period. A calf stranded on the southeast side of San Nicolas Island in January 1994 (G. Smith, Point Mugu Environmental Division, personal communication 1998).

Blue Whale

Blue whales may occasionally occur within 3 NM (5.6 kilometers) of San Nicolas Island. Blue whales are common in summer somewhat beyond 3 NM (5.6 kilometers) west of San Nicolas Island (Figure 3.7-49). This species was occasionally sighted "near" San Nicolas Island in autumn during the mid-1960s to early 1980s (Dohl et al. 1981), and a blue whale stranded on the north side of the island in August 1993 (G. Smith, Point Mugu Environmental Division, personal communication 1998).

Fin Whale

No fin whales were sighted within 3 NM (5.6 kilometers) of San Nicolas Island during the studies summarized here (Figure 3.7-50). Fin whales are found primarily on the continental slope and in offshore waters. However, they have been seen near San Nicolas Island during late spring and summer (Leatherwood 1987; Clark et al. 1998).

Minke Whale

Minke whales have occasionally been seen near San Nicolas Island, but the sightings have been more than 3 NM (5.6 kilometers) from shore (Figure 3.7-51). The two sightings within Range Area M3 were of single whales in June and July.

3.7.4.3 Pinnipeds

Three species of pinnipeds presently breed on San Nicolas Island. They include the harbor seal, the northern elephant seal, and the California sea lion. The Guadalupe fur seal may have bred there historically and has been an occasional recent visitor. Steller sea lions have been sighted on the island in

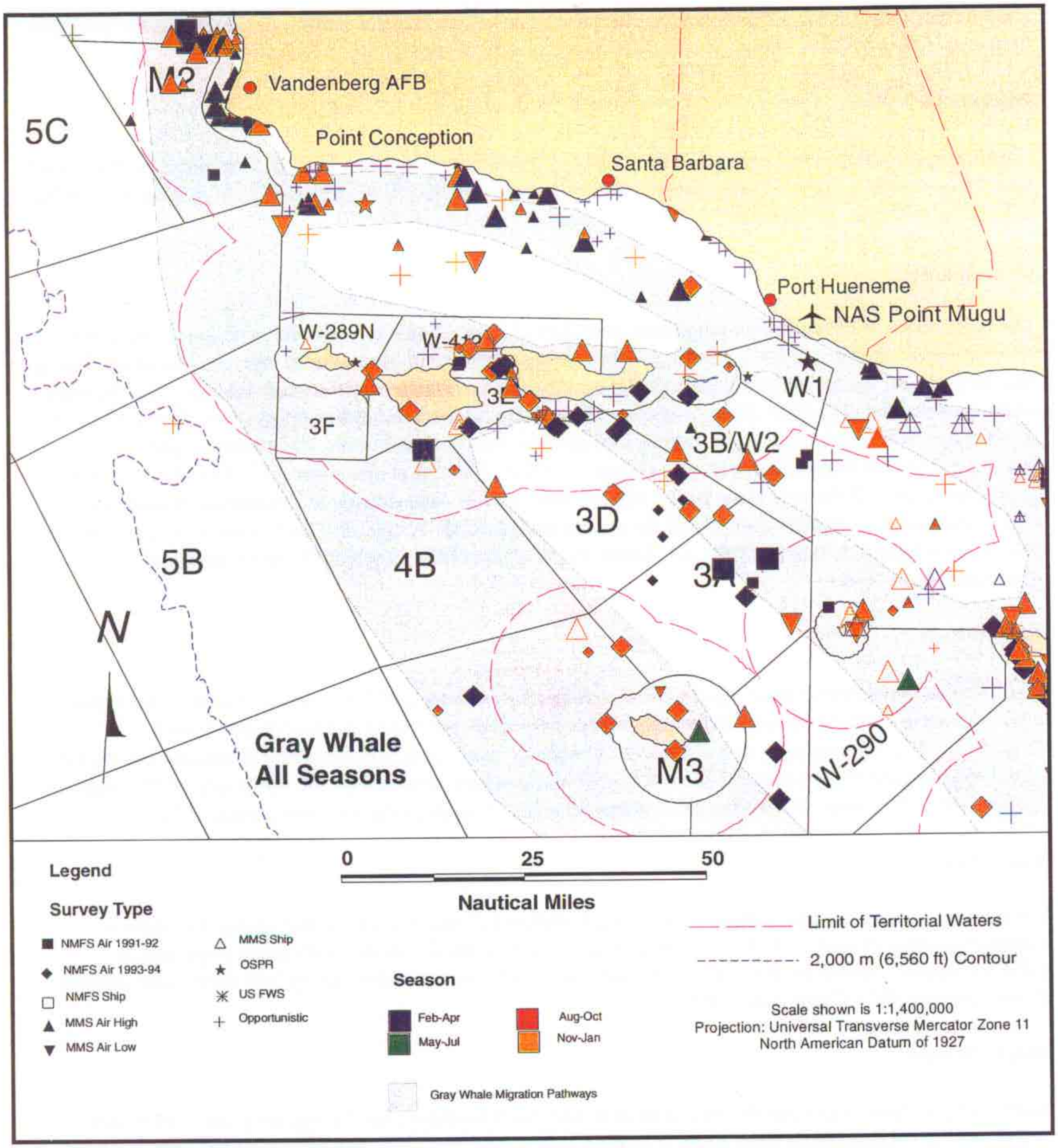


Figure 3.7-82
Sightings of gray whales in and near the Channel Islands during the 1975-96 surveys listed in Table 3.7-3.
Survey effort was not uniform throughout the area or at different times of the year; thus sightings cannot be assumed to represent relative abundance either geographically or seasonally. Small and large symbols denote sightings of single animals vs. 2 or more animals, respectively. Generalized migration routes, from Bonnell and Dailey (1993), are superimposed on the actual sightings.

the past (Bartholomew 1951), but apparently did not breed there (Stewart and Yochem 1984). They are not likely to occur there now given their general abandonment of southern California waters.

For census purposes, the island's coastline has been divided into haul-out areas with alphabetical and numerical designations, which have varied depending on the species being censused (Figure 3.7-83).

Harbor Seal

The general biology of harbor seals is described in Section 3.7.2.3 and is not repeated here. Harbor seals remain near their terrestrial haul-out sites and frequently haul out on land throughout the year, at least for brief periods. However, at most haul-out sites, large numbers of seals are seen on land only during the pupping, nursing, and molting periods. The pupping period extends from late February to early April, with a peak in pupping in late March. The nursing period extends from late February to early May. Females and pups haul out for long periods at this time of year. The molting period is in late May to June, and all ages and sexes of harbor seals haul out at this time.

During August to February, smaller numbers of seals are seen hauled out at any given time (Figures 3.7-56 and 3.7-84). Due to differences in timing of molt by different age and sex groups, and due to different hauling out patterns of different individual seals, not all seals are hauled out at the same time, even at the peak of the haul-out season. Thus peak counts represent, at most, 65 to 83 percent of the individual seals that use a haul-out site (Huber 1995; Hanan 1996). During winter, when seals spend most of their time feeding at sea, the number of seals hauled out at most sites is approximately 15 percent of the maximum count during the peak of haul out (i.e., 10 to 12 percent of those using the site).

On San Nicolas Island, most seals haul out at several specific traditionally-used sandy, cobble, and gravel beaches (Figure 3.7-85). A few seals haul out at onshore and offshore ledges and reefs, mostly during the pupping and molting seasons (Stewart and Yochem 1994). There is no recent published information on the number of harbor seals at specific haul-out sites on San Nicolas Island, but total numbers of seals using this island have not changed much since 1981 and 1982 when Stewart and Yochem (1984) surveyed it. Harbor seals hauled out and gave birth at 7 sites and used 13 others sporadically. Sites 231 and 266 were the most consistently used haul-out sites throughout the year and site 270 had significant numbers of seals during the pupping and molting periods (Figure 3.7-83). Two of these sites (231 and 270) were also the most heavily-used sites during the 1975-1978 surveys of Bonnell et al. (1981). Recent information indicates that the latter site is still heavily used (Figure 3.7-83; NAWC 1996).

There is sex and age segregation at many of the sites. Some sites are used primarily by adult females and pups, others by weaned pups and juveniles, and still others by adult and subadult males. Unlike locations farther north where many factors contribute to the daily pattern of haul-out behavior, highest numbers of harbor seals haul out on the Channel Islands during the late afternoon (15:00-16:00 hours), with other environmental factors apparently causing little variation in haul-out behavior (Stewart and Yochem 1994).

Harbor seal abundance increased at San Nicolas Island from the 1960s until 1981, but since then the average counts have not changed significantly. The mean annual increase from 1982 to 1995 was 0.02 percent (±0.036 SE, Hanan 1996). Counts from 1982 to 1994 have fluctuated between approximately 465 and 700 harbor seals based on peak ground counts (Stewart and Yochem 1994) and between 139 and 694 seals based on single counts during annual aerial photographic surveys (Beeson and Hanan 1994; Figure 3.7-86). The most recent aerial count at San Nicolas Island was of 457 harbor seals during 1994.

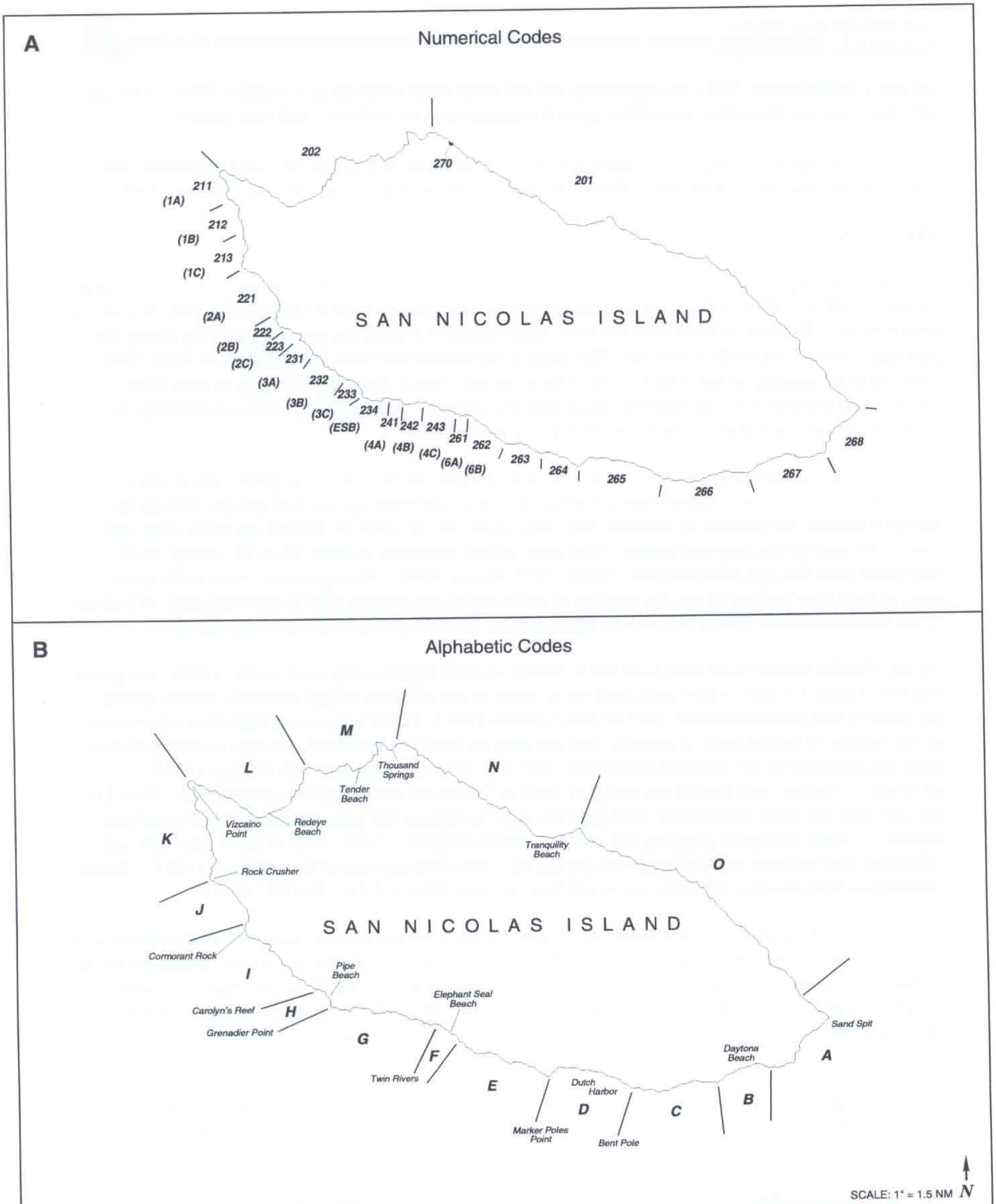


Figure 3.7-83
San Nicolas Island showing census areas and associated *(A)* numerical codes (Stewart and Yochem 1984) and *(B)* alphabetic codes (Lowry n.d.) to identify census areas.

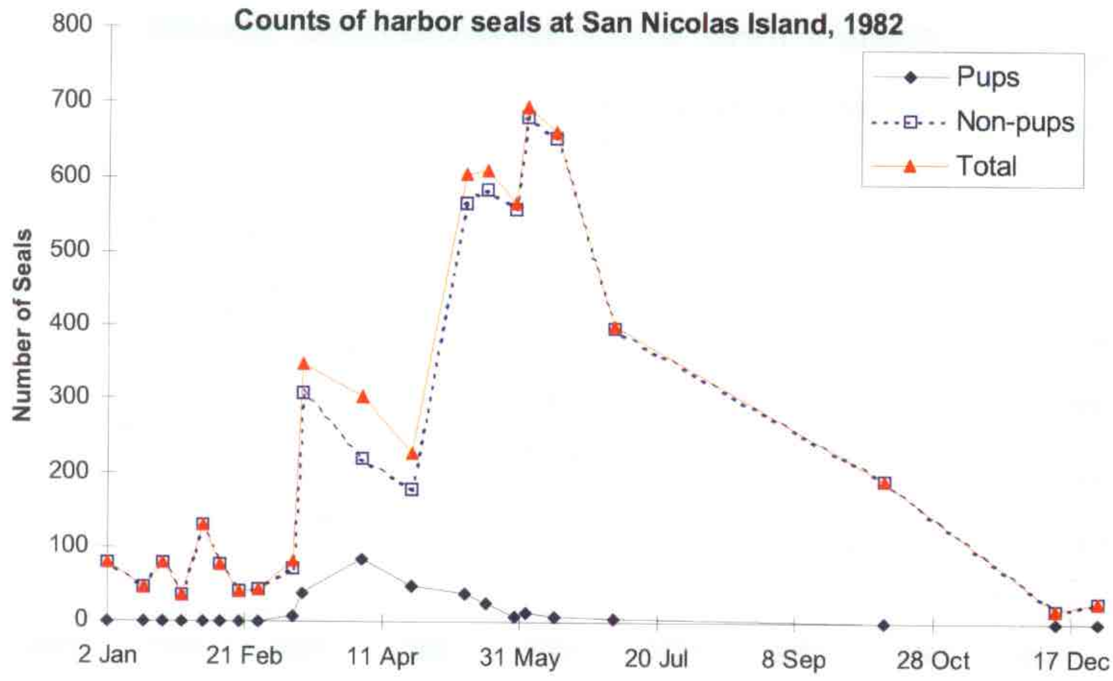


Figure 3.7-84
Counts of harbor seals throughout the year on San Nicolas Island, 1982.
From Stewart and Yochem (1984).

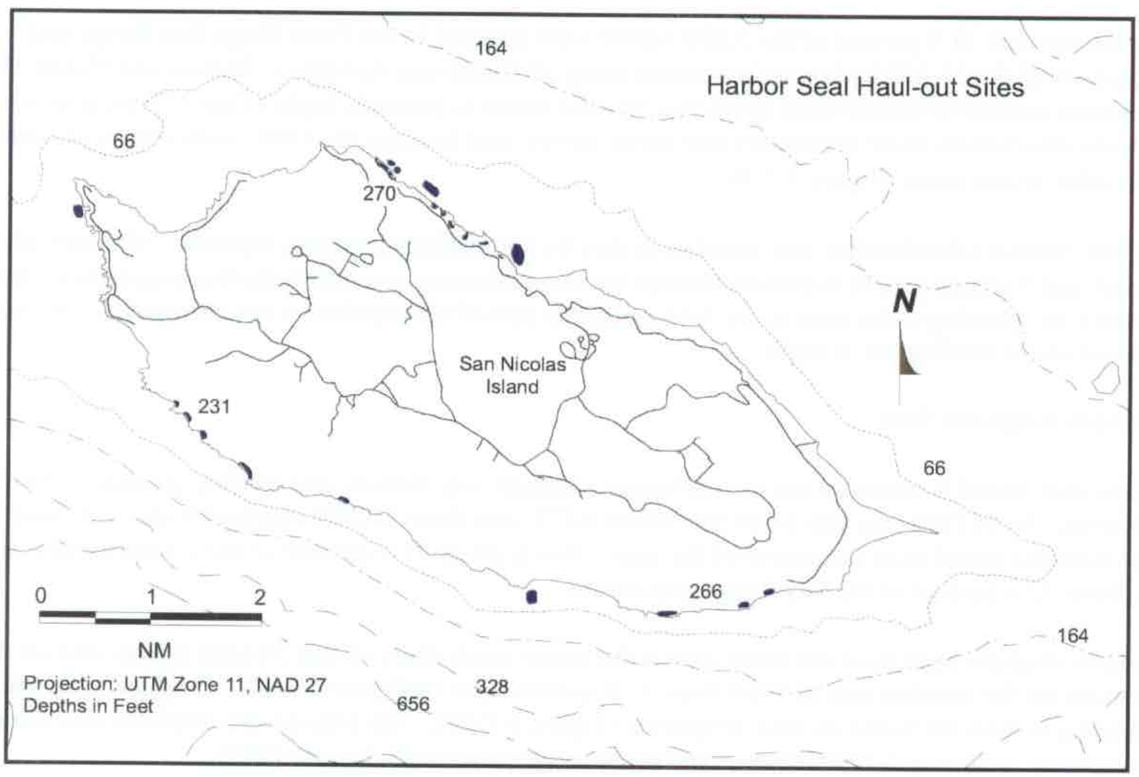


Figure 3.7-85
Map of San Nicolas Island showing areas used by harbor seals.

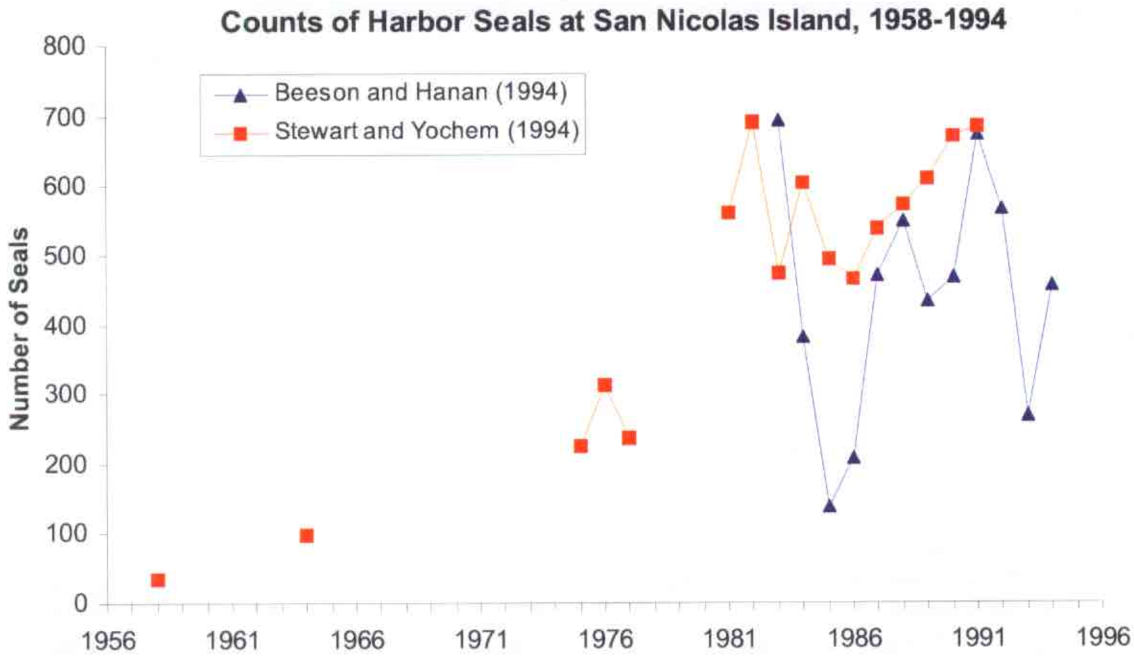


Figure 3.7-86
Counts of harbor seals at San Nicolas Island, 1958-94.
Aerial counts were conducted by Beeson and Hanan (1994) and ground counts by Stewart and Yochem (1994).

This represented 11.9 percent of the 3,826 harbor seals counted in the Point Mugu Sea Range and 2.1 percent of the 21,462 harbor seals counted along all California shorelines (Beeson and Hanan 1994). The actual number of harbor seals using San Nicolas Island is probably higher than 457 because not all seals are detected on shore during any one aerial survey, and because the 1994 count was lower than in some other recent years (Figure 3.7-86).

The San Nicolas Island harbor seal population may be approaching carrying capacity. Alternatively, Stewart and Yochem (1994) hypothesized that recent counts may not reflect the true population; seals may now be spending more time at sea feeding and/or part of the population has changed its haul-out behavior and is hauling out at night.

Northern Elephant Seal

San Nicolas Island is currently the second largest elephant seal rookery and hauling grounds in southern California. As of 1995, the pup count was about 6,575, and about 23,000 elephant seals of all ages and sexes used the island over the course of the year. This is about 27.4 percent of the California population and about 32.4 percent of the Sea Range population.

Northern elephant seals haul out along almost the entire south shore of San Nicolas Island, and on the north side on the beaches east of West Point (=Vizcaino Point in Figure 3.7-87). Elephant seals are expanding around the island as time progresses (Figure 3.7-88). The present-day elephant seal usage patterns may in no way resemble pre-exploitation usage patterns (Schwartz 1994).

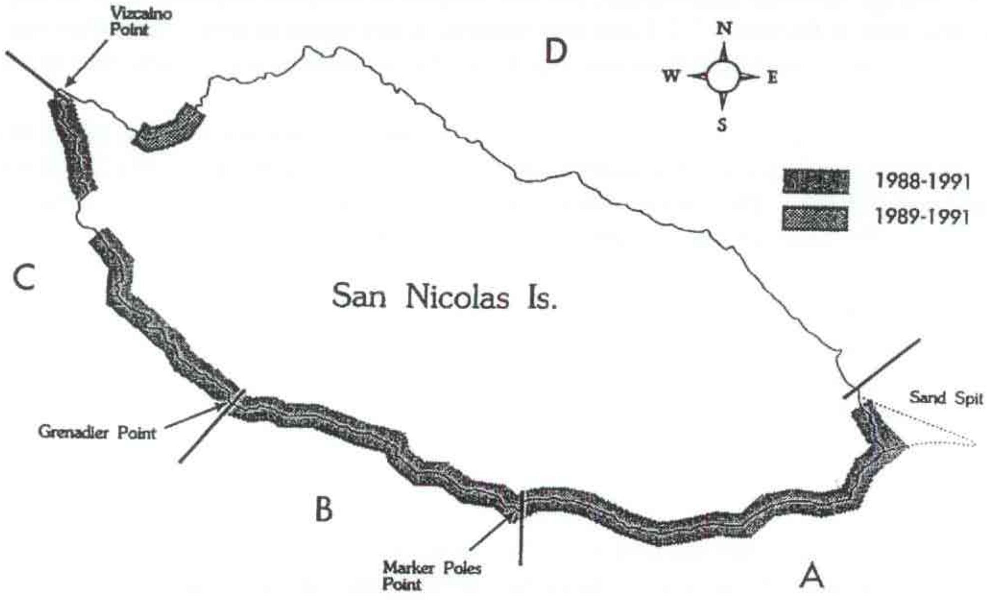


Figure 3.7-87
Map of San Nicolas Island with shaded areas to show where northern elephant seals were photographed and area codes used to document counts in specific areas of the island. From Lowry et al. (1992).

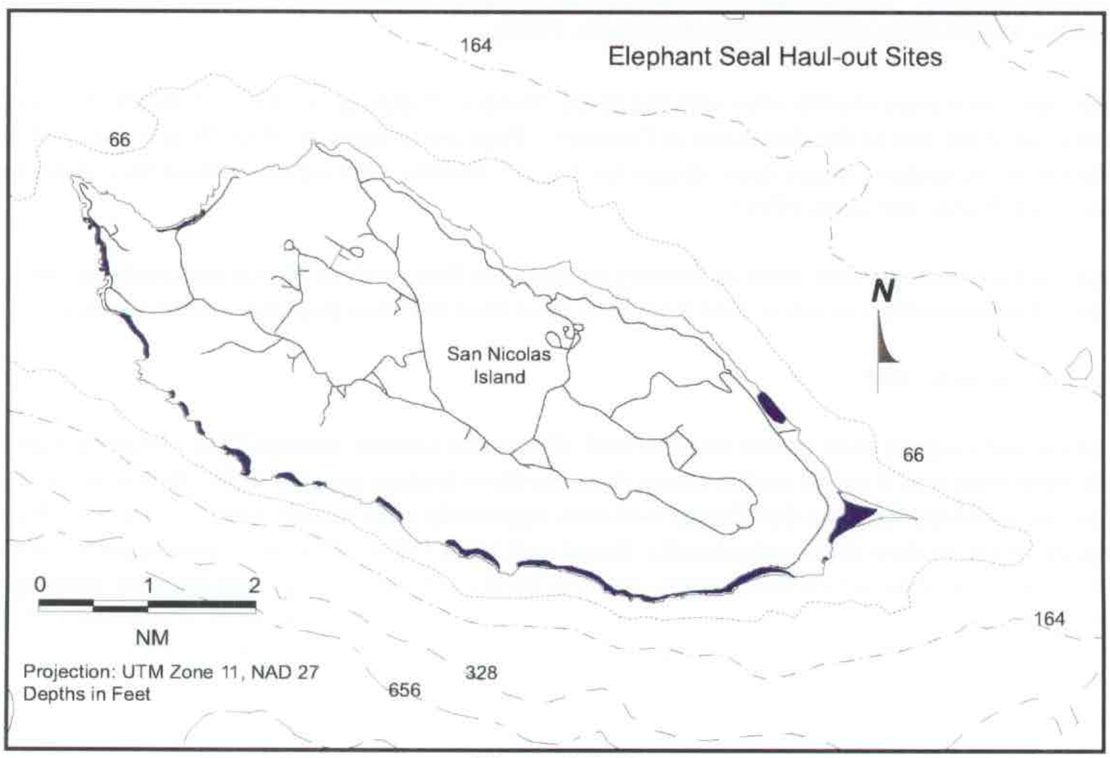


Figure 3.7-88
Map of San Nicolas Island showing areas used by northern elephant seals.

The general biology, seasonal distribution, and movements of northern elephant seals through the Sea Range are described in Section 3.7.2.2 and that material is not repeated here. The following is a description of the use of terrestrial haul-out sites by northern elephant seals in and near the Sea Range.

Northern elephant seals haul out at traditional sites. They prefer gradually sloping, sandy beaches or sand spits. If sandy beaches are not available, they will haul out on pebbles, or as a last resort, on boulders and rocky shores. The timing of haul out by various age and sex categories of seals is depicted in Figure 3.7-53. The haul out can be subdivided into four phases:

1. The breeding season,
2. Female and juvenile molt,
3. Adult male molt, and
4. Juvenile haul out.

Breeding Season

Haul out for the breeding season starts in early December with the arrival of adult males. Older bulls tend to arrive the earliest. By the end of December, all bulls are hauled out at the rookeries. Elephant seals are highly polygynous. Males establish a dominance hierarchy and defend harems on the beach during the mating season. Vocal activity is important in maintaining social structure and appears to be greatest in the hours following sunset (Shipley and Strecker 1986).

Pregnant females begin to arrive in mid-December and peak numbers are present at the end of January and in early February. Numbers of females then begin to decline until the first week in March when they have left the rookery. Younger adult males begin to leave the rookery in late February, but some of the older males remain there until late March (Clinton 1994).

Females have their pups shortly after arriving at the rookery. Pupping occurs from the third week in December until the end of the first week in February. Pups are weaned at 24 to 28 days old, and they are abandoned on the rookery where they remain for 2 to 2.5 months. During this period they undergo their first molt (Le Boeuf and Laws 1994).

Breeding occurs from the first week in January through the first week in March and peaks in mid-February. Females return to sea to feed once they have bred and their pups have been weaned.

Female and Juvenile Molt

The female and juvenile molt period starts in mid-March and extends through May. Most females that weaned their pups 6 to 8 weeks earlier return from northern feeding areas to molt. However, some females and juveniles from the Sea Range rookeries apparently molt farther north (i.e., at Año Nuevo) rather than return to their natal rookeries (Le Boeuf and Laws 1994). The molt takes approximately one month to complete, after which the animals return to northern feeding areas until the next pupping and breeding season. Juvenile animals (one to four years old) of both sexes also molt at this time. Eighty percent of pups have left the rookery by the end of April and the remainder leave in May.

Male Molt

The male molt period occurs during June through August when only adult male animals are present at haul-out sites. These are the same animals that were present at the rookeries during December to March.

They return to their breeding rookeries to molt after feeding at sea for three to four months. Unlike the sequence during the breeding season, it is the younger males that arrive at the molting sites first and the older males arrive later in the summer (Clinton 1994).

Juvenile Haul-out

The juvenile haul-out phase extends from September through November with pubertal subadult males arriving in November and remaining until December. The peak of juvenile haul-out is in October and most (except for pubertal subadult males) have left by the time that adult males arrive in early December (Le Boeuf and Laws 1994).

Population Size

NMFS SWFSC has censused northern elephant seals at San Nicolas Island since 1988. Surveys are conducted during the peak of the breeding season in late January to early February, and late in the breeding season in mid-to-late February (Figure 3.7-89). Total counts on the island for the years 1988 to 1995 are given in Table 3.7-7 and counts by haul-out area for the years 1988 to 1994 are given in Table 3.7-8. The numbers in these tables do not provide an estimate of the total number of seals using each haul-out site because:

- only part of the breeding population is present at the rookeries even during the peak of the breeding season (some early-arriving adult females have already departed), and
- there is different timing of occupation of the haul-out sites by different age and sex cohorts during different haul-out phases, as described above.

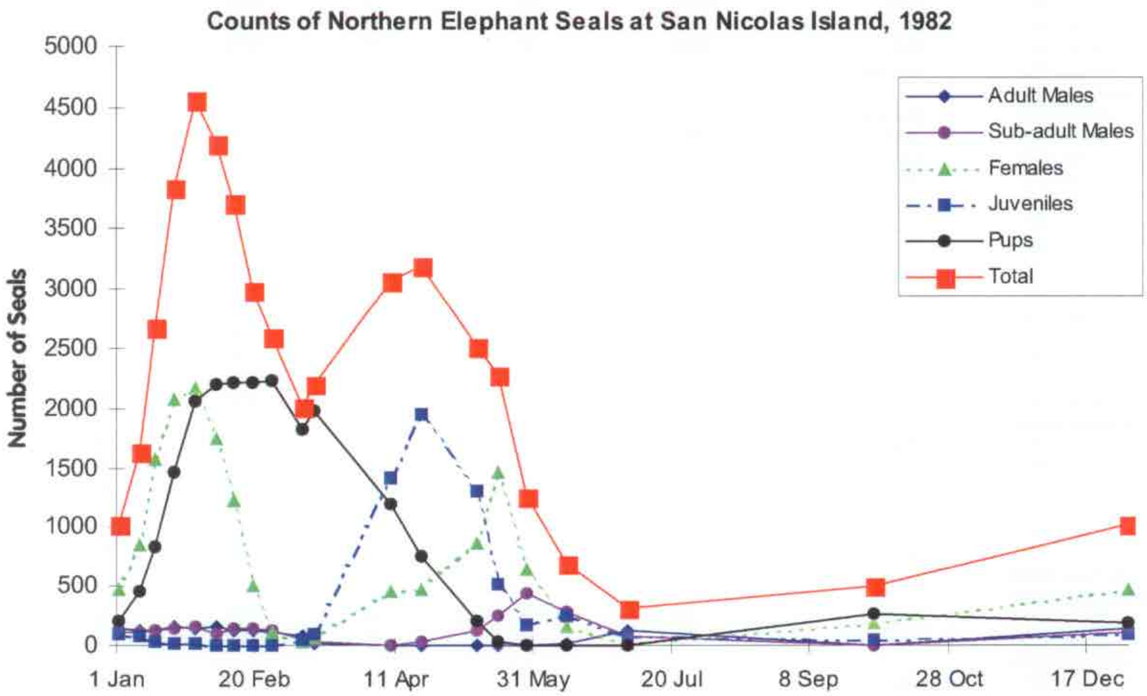


Figure 3.7-89
Counts of northern elephant seals throughout the year at San Nicolas Island, 1982. Plotted from Table 1 in Stewart and Yochem (1984).

Table 3.7-7. Counts of northern elephant seals, *Mirounga angustirostris*, at San Miguel, San Nicolas, Santa Rosa, and Santa Barbara islands, California, obtained from 228-mm- (1985-86) or 126-mm-format (1988-95) aerial color photographs (augmented with visual counts from sites that were not photographed during the survey). Juveniles were not counted in 1985 and 1986. No counts are given for the peak breeding-season surveys at San Miguel Island in 1987 and 1992 owing to partial survey coverage that resulted in incomplete counts. From Lowry et al. (1996).

		Pups			Subadults and Adults		
Survey Date	Survey Coverage[1]	Alive and Unknown	Decomposed Carcasses	Juveniles	♀[2]	♂	Unknown Sex
San Miguel Island							
Peak breeding season							
31 Jan 1985	Partial[3]	9,102	71		8,748	1,512	0
1 Feb 1986	Near total	9,622	71		8,651	1,607	0
1-2 Feb 1987	Partial						
1 Feb 1988	Near total	10,146	168	3	10,266	1,705	0
28 Jan 1989	Total	10,114	147	20	10,461	1,663	7
3 Feb 1990	Total	12,185	158	6	10,048	1,990	0
1 Feb 1991	Total	12,883	180	7	11,898	2,065	0
2 Feb 1992	Partial						
29 Jan 1993	Total	13,096	257	22	13,145	2,310	0
28 Jan 1995	Total	10,947	258	25	13,282	2,713	0
Late breeding season							
22 Feb 1985	Partial[3]	9,585	80		1,241	1,308	0
21 Feb 1986	Near total	9,555	67		1,338	1,410	0
15 Feb 1988	Near total	10,901	182	0	4,842	1,493	3
16 Feb 1989	Total	11,117	175	3	3,772	1,648	0
19 Feb 1990	Total	12,241	183	1	2,320	1,779	3
18 Feb 1991	Total	13,029	162	1	3,358	2,084	0
17 Feb 1992	Total	13,116	227	6	4,282	2,272	1
15 Feb 1993	Total	13,720	180	5	5,489	2,292	0
13 Feb 1994	Total	14,616	222	3	8,010	2,403	2
15 Feb 1995	Total	13,012	450	3	7,556	2,411	0
San Nicolas Island							
Peak breeding season							
28 Jan 1989	Total	4,124	50	16	4,313	549	3
3 Feb 1990	Total	4,092	55	5	3,439	475	3
2 Feb 1991	Total	4,053	67	2	4,019	502	0
3 Feb 1992	Total	5,482	78	5	4,745	634	1
29 Jan 1993	Total	4,940	63	23	4,878	554	0
28 Jan 1995	Near total	5,218	62	27	6,232	724	0
Late breeding season							
15 Feb 1988	Near total	3,120	34	0	1,732	430	0
16 Feb 1989	Total	4,688	63	0	1,649	537	0
19 Feb 1990	Total	4,079	52	2	976	425	2
18 Feb 1991	Total	4,547	51	3	1,316	469	0
17 Feb 1992	Partial[4]	5,387	63				
15 Feb 1993	Total	5,171	37	8	1,973	602	0
13 Feb 1994	Total	5,727	63	7	2,998	648	3
15 Feb 1995	Total	6,486	89	2	3,590	673	0
Santa Rosa Island							
Peak breeding season							
2 Feb 1991	Total	86	0	0	86	37	0
3 Feb 1992	Total	67	0	0	68	52	0
29 Jan 1993	Total	110	0	0	119	72	0
28 Jan 1995	Total	143	0	2	175	69	0
Late breeding season							
19 Feb 1990	Total	23	0	0	4	14	0
18 Feb 1991	Total	83	0	0	24	45	0
17 Feb 1992	Total	64	0	0	29	40	0
15 Feb 1993	Total	123	0	0	48	57	0
13 Feb 1994	Total	315	0	0	173	141	0
15 Feb 1995	Total	186	0	0	114	81	0
Santa Barbara Island							
Peak breeding season							
29 Jan 1993	Total	53	0	0	109	9	0
28 Jan 1995	Total	28	0	0	113	18	0
Late breeding season							
15 Feb 1993	Total	34	0	0	21	14	0
13 Feb 1994	Total	47	0	0	45	21	0
15 Feb 1995	Total	27	0	0	51	10	0

[1] Survey coverage: Total = all sites were photographed or visually inspected; Near total = sites not photographed or visually inspected were estimated to have trivial numbers of seals relative to the total count; and Partial = sites inhabited by large numbers of seals were not photographed.

[2] The count of adult females may contain an extremely small percentage (estimated to be ≤1%) of males that are of similar size as adult females.

[3] The counts of pups, adult females, and subadult or adult males include counts made from high-altitude photographs for sites not photographed at low altitude.

[4] Counts of pups from the peak breeding-season survey were substituted for sites, or portions of sites, that were not photographed.

Table 3.7-8. Counts of northern elephant seals at San Nicolas Island during the breeding season, 1988 to 1994. Figure 3.7-83B shows the locations of area codes. Only pups were counted in 1988 and 1989. All seals were counted from aerial photographs. Adults were only counted during peak breeding season; pups were counted during peak and late breeding season (highest count is given). From Lowry (n.d.).

Area	1988	1989			1990			1991			1992			1993			1994
	Pups	Pups	Adults & Juveniles	Total	Pups	Adults & Juveniles	Total	Pups	Adults & Juveniles	Total	Pups	Adults & Juveniles	Total	Pups	Adults & Juveniles	Total	Pups
A	7	86	100	**186**	52	58	**110**	69	85	**154**	143	161	**304**	170	213	**383**	208
B	144	203	220	**423**	251	241	**492**	265	263	**528**	479	448	**927**	463	474	**937**	622
C	235	525	521	**1,046**	424	399	**823**	447	449	**896**	777	715	**1,492**	559	566	**1,125**	715
D	311	366	390	**756**	403	392	**795**	351	373	**724**	519	475	**994**	463	492	**955**	540
E	348	583	601	**1,184**	476	827	**1,303**	646	584	**1,230**	647	631	**1,278**	586	583	**1,169**	692
F	620	491	469	**960**	482	441	**923**	506	471	**977**	617	575	**1,192**	589	602	**1,191**	464
G	222	576	623	**1,199**	440	408	**848**	495	510	**1,005**	499	508	**1,007**	435	434	**869**	516
H	577	731	707	**1,438**	670	600	**1,270**	732	671	**1,403**	668	650	**1,318**	684	681	**1,365**	629
I	234	587	589	**1,176**	449	378	**827**	504	483	**987**	487	455	**942**	482	513	**995**	613
J	456	599	633	**1,232**	497	551	**1,048**	572	585	**1,157**	691	704	**1,395**	736	792	**1,528**	769
K	0	0	28	**28**	0	12	**12**	0	22	**22**	1	21	**22**	2	33	**35**	2
L		4	0	**4**	2	5	**7**	11	23	**34**	32	41	**73**	38	64	**102**	17
M		0	0	**0**	0	1	**1**	0	1	**1**	0	0	**0**	0	0	**0**	3
N		0	0	**0**	0	1	**1**	0	0	**0**	0	0	**0**	0	2	**2**	0
O		0	0	**0**	0	1	**1**	0	2	**2**	0	0	**0**	0	6	**6**	0
Total	**3,154**	**4,751**	**4,881**	**9,632**	**4,146**	**4,315**	**8,461**	**4,598**	**4,522**	**9,120**	**5,560**	**5,384**	**10,944**	**5,207**	**5,455**	**10,662**	**5,790**

In 1994, elephant seal pups were counted in all areas except the north-central coast (areas N and M) (Table 3.7-8; Figure 3.7-83B). More than 450 pups were found in each area along the south coast from Daytona Beach (area B) to Rock Crusher point (area J). The most populated area has been area J on the southwest part of the island. The total pup count on San Nicolas Island was 6,575 in 1995. A multiplication factor of "3.5 times the number of pups born" is used to estimate the size of growing elephant seal populations (Boveng 1988; Barlow et al. 1993). Based on this, about 23,000 seals of all ages and both sexes may use San Nicolas Island over the course of the year. This represents about 27 percent of the California stock and 32 percent of the population that occurs in the Sea Range.

The northern elephant seal population has been steadily increasing on San Nicolas Island (Figure 3.7-61). From 1988 to 1995 the pup counts increased at an average rate of 15.4 percent per year. However, the growth rate of the California population as a whole appears to have slowed in recent years. For all of California, the rate of growth was 14.9 percent for 1964 to 1979, 10.2 percent for 1980 to 1985, and 8.41 percent for 1987 to 1991. Slopes for these periods are significantly different (Barlow et al. 1993). It is possible that the elephant seal population is approaching the carrying capacity of its environment. If so, the continued high rate of increase on San Nicolas Island, while other populations are growing more slowly or stabilizing, suggests that suitable haul-out habitat, rather than abundance of food, is limiting population growth elsewhere because animals from the different haul-out sites all feed in the same general area. This theory is also supported by the observed expansion of rookery sites and occupation of formerly unused sites on San Nicolas Island. Elephant seals began using Daytona Beach (area B in Table 3.7-8 and Figure 3.7-83B) as a pupping area in 1988 when 144 elephant seal pups were born there (Lowry 1995 *in* NAWC Point Mugu 1995). In 1995, approximately 1,000 pups were born there, and elephant seals are now utilizing the entire beach (Lowry 1995 *in* NAWC Point Mugu 1995). Table 3.7-8 shows that use of areas K and L at the west end of San Nicolas Island has also increased over the 1988 to 1994 period, although not as dramatically as at Daytona Beach.

In summary, San Nicolas Island has the second largest population of northern elephant seals in southern California. Since 1988 the San Nicolas Island population has continued to increase at an average rate of 15.4 percent per year. As of 1995, approximately 23,000 elephant seals of all ages and sexes used San Nicolas Island over the course of the year. This is about 27 percent of the California stock and 32 percent of the population that occurs in the Sea Range. Northern elephant seals haul out at traditional sites twice annually: once to breed and give birth, and a second time to molt. When not hauled out, they travel to feeding areas far north of the Sea Range. Bulls haul out in early December to early February to defend territories and breed, and during June to August to molt. Adult females haul out for one month in mid-December to early March to give birth and breed, and during mid-March to May to molt. Juveniles and nonbreeding adults molt during this latter period; they return to San Nicolas Island to haul out from September through November, with pubertal subadult males remaining until adult males arrive in December. Haul-out areas occur around much of the western, southern, and eastern sides of San Nicolas Island, and are expanding around the island.

California Sea Lion

The general biology, seasonal distribution, and timing of haul out of California sea lions are described in Section 3.7.2.2 and are not repeated here.

The population on San Nicolas Island is growing rapidly (Figure 3.7-90), and California sea lions have recently begun to occupy areas that were not formerly used. During the 1980s, California sea lions were rarely found east of Elephant Seal Beach (area F in Figure 3.7-83B), but recently they have been found on many beaches along the southern shore east to Daytona Beach (Figure 3.7-91). The numbers of pups

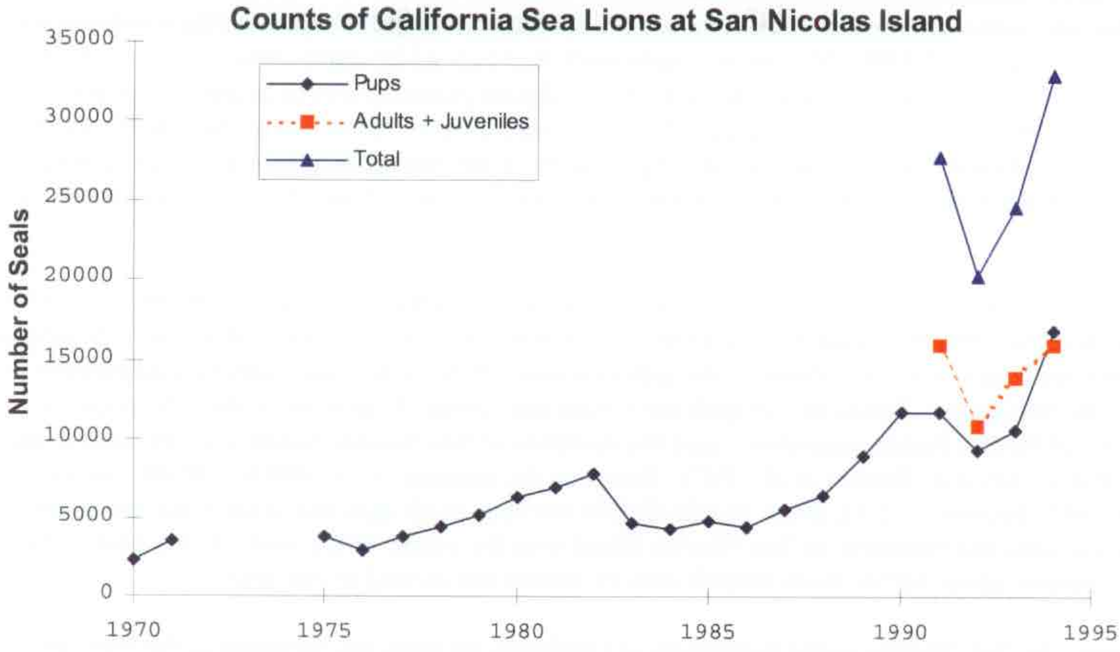


Figure 3.7-90
Counts of California sea lions at San Nicolas Island, 1970-94.
Plotted from Table 1 in Lowry et al. (1992) and Table 3 in Lowry (n.d.).

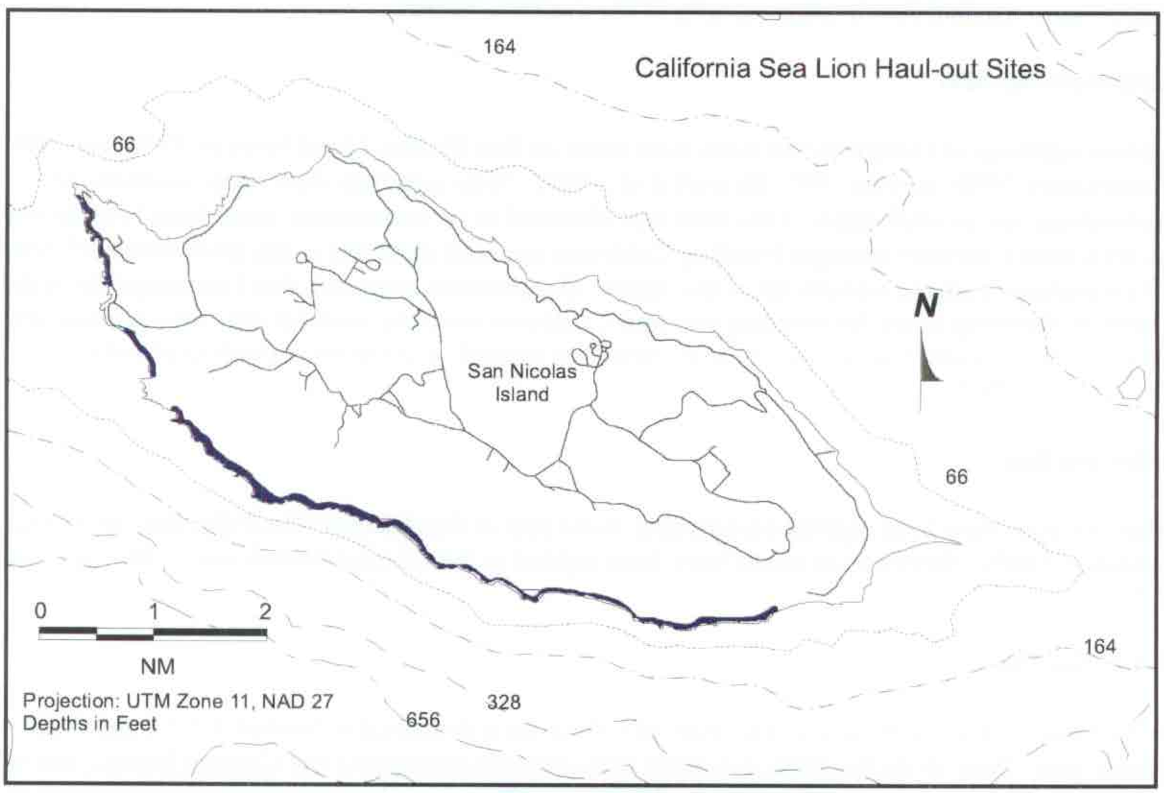


Figure 3.7-91
Map of San Nicolas Island showing areas used by California sea lions.

and non-pups counted in each survey area around the island in 1990 to 1994 are given in Table 3.7-9. California sea lions were present in all areas around the island except for area A on the southeast corner (Table 3.7-9; Figure 3.7-83B). Maximum counts were found along the south coast in area G. El Niño events have caused substantial reductions in numbers of pups produced and in counts of non-pups at the rookeries in 1983, 1992, and 1993 (Figure 3.7-90). To date there is no indication that California sea lions on San Nicolas Island have reached the carrying capacity of the surrounding habitat, except during these El Niño years when sea lions may have to spend more time feeding and may have to forage farther from rookeries.

While the U.S. stock of California sea lions has increased at 8.3 percent per year from 1983 to 1995, the population on San Nicolas Island has increased at 21.4 percent per year. Almost all of the U.S. stock of California sea lions occurs in California and approximately 95 percent of the California population is found in the Sea Range. Based on extrapolations from pup counts, 47 percent of the U.S. stock, or 49 percent of the Sea Range population, used the shoreline of San Nicolas Island to breed, pup, or haul out in 1994 (Lowry n.d.; Barlow et al. 1997). Based on the estimate of 167,000 to 188,000 for the U.S. stock in 1995 (Section 3.7.2.3), about 78,000-88,000 sea lions of all ages and sexes were associated with the haul-out sites and rookeries on San Nicolas Island over the course of the year. At the peak of the breeding season, about half of these animals may be hauled out on land at one time.

In summary, the San Nicolas Island population of California sea lions has increased at the high rate of about 21.4 percent per year since 1983. The 1995 size was 78,000 to 88,000 animals of all ages and sexes, which was about 47 percent of the U.S. population. Of these, about half may be hauled out on land at one time during the peak of the breeding season. Sea lions have recently occupied new areas on San Nicolas Island, and they now occur along most of the southern shore. There is no evidence that numbers have reached the carrying capacity of the available habitat.

Guadalupe Fur Seal

Eighteen sightings of Guadalupe fur seals were made on San Nicolas Island between 1949 and 1986 (Bartholomew 1950; Stewart 1981; Stewart et al. 1987). Most sightings were either juveniles of undetermined sex or adult males. One male was observed in six consecutive years from 1981 to 1986; it was defending a territory amongst breeding California sea lions along the south shore about 3.7 NM (6.9 kilometers) from the western tip of the island. Observations suggested that Guadalupe fur seals are capable of obtaining space for breeding amongst California sea lions, and that they may successfully recolonize the Channel Islands once they are abundant enough to establish a breeding population (Stewart et al. 1987).

Steller Sea lion

Steller sea lions have been sighted occasionally in the past at San Nicolas Island (Bartholomew and Boolootian 1960). However, no adults have been sighted in the Channel Islands since 1983 (see Section 3.7.2.3).

3.7.4.4 Sea Otter

The distribution and life history of sea otters in California is described in Section 3.7.2.4 and is not repeated here. Prior to the fur trade, sea otters were common throughout the Channel Islands, and were present in sufficient numbers at San Nicolas Island to support some level of hunting by natives on the

Table 3.7-9. Counts of California sea lions at San Nicolas Island in July (during late breeding season), 1990 to 1994. Figure 3.7-83B shows the locations of area codes. Only pups were counted in 1990. The counts in 1991 were made on the ground; all others are from aerial photographs. From Lowry (n.d.).

Area	1990	1991			1992			1993			1994		
	Pups	Pups	Non-Pups	Total	Pups	Non-Pups	Total	Pups	Non-Pups	Total	Pups	Non-Pups	Total
A	0	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**
B	0	0	0	**0**	0	0	**0**	8	446	**454**	80	557	**637**
C	0	0	471	**471**	7	316	**323**	18	361	**379**	192	628	**820**
D	30	28	1,241	**1,269**	56	1,001	**1,057**	96	967	**1,063**	249	647	**896**
E	0	41	2,024	**2,065**	101	728	**829**	421	1,337	**1,758**	1,633	1,759	**3,392**
F	770	920	1,324	**2,244**	460	619	**1,079**	519	679	**1,198**	695	667	**1,362**
G	5,464	4,283	4,490	**8,773**	4,135	3,235	**7,370**	4,628	4,012	**8,640**	6,519	4,759	**11,278**
H	1,874	2,389	1,954	**4,343**	1,178	988	**2,166**	1,511	1,474	**2,985**	2,099	1,668	**3,767**
I	3,167	3,189	2,927	**6,116**	2,571	2,695	**5,266**	2,414	2,804	**5,218**	3,505	3,232	**6,737**
J	0	0	301	**301**	0	188	**188**	0	444	**444**	0	351	**351**
K	461	977	1,197	**2,174**	840	1,176	**2,016**	980	1,459	**2,439**	1,917	1,752	**3,669**
Total	**11,766**	**11,827**	**15,929**	**27,756**	**9,348**	**10,946**	**20,294**	**10,595**	**13,983**	**24,578**	**16,889**	**16,020**	**32,909**

island (Woodhouse 1977 *in* Schwartz 1994). Commercial hunting probably began there by 1811 and by the 1850s sea otters were possibly completely hunted out (Schwartz 1994).

From 1987 to 1990, 139 California sea otters were translocated from central California to San Nicolas Island in an attempt to re-establish sea otter populations there. Of this "experimental population," at least 17 remained at the island as of 1995 (Ralls et al. 1996; USFWS 1996). Some of the transported animals returned to the area where they were trapped and others died, but the fate of most is unknown. The number of sea otters at San Nicolas Island has been relatively stable since November 1989 (USFWS 1996), and to date at least 10 pups have been successfully weaned into the population. The reason for the lack of population growth remains unknown. However, the demographic pattern observed at San Nicolas Island to date is consistent with other successfully translocated sea otter populations, where numbers initially declined precipitously, then stabilized, and eventually increased (USFWS 1996).

San Nicolas Island sea otters occur throughout the year in subtidal kelp beds at the western end of the island (NAWC 1996) and, in smaller numbers, on the northern side of the island. Their range extends from Vizcaino Point to Dutch Harbor, and from Thousand Springs to Tranquility Beach (Figure 3.7-92). The kelp beds in these areas provide the primary cover and foraging areas preferred by southern sea otters.

3.7.5 Other Channel Islands

The other Channel Islands in or adjacent to the Sea Range include San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara islands. Eight species of odontocetes and five species of mysticetes were recorded within 3 NM (5.6 kilometers) of these "Other Channel Islands" during the studies listed in Table 3.7-3. Two more species of cetaceans, the sperm whale and northern right whale, have been reported there during other studies not included in the sighting maps. However, the nearshore areas of the Channel Islands are relatively important only for minke and gray whales. The other cetacean species utilize primarily offshore waters and are seen infrequently near the Channel Islands. Leatherwood et al. (1987) provides a detailed account of cetacean sightings and strandings in the Channel Islands up to the mid-1980s.

Some of the "Other Channel Islands" are very important to pinnipeds, including the harbor seal, northern elephant seal, California sea lion, and the northern fur seal. Small numbers of sea otters dispersing from San Nicolas Island and perhaps from the central California population have been seen near some of the other islands, particularly San Miguel Island.

3.7.5.1 Odontocetes (Toothed Whales)

Although 9 species of odontocetes have been seen in nearshore waters within 3 NM (5.6 kilometers) from the "Other Channel Islands," these nearshore areas are not preferred habitat or important feeding, mating, or resting locations for any of these species. All of these species are found in higher numbers in continental slope and offshore waters farther offshore from the Channel Islands. For example, there have been moderate numbers of sightings of common and Pacific white-sided dolphins near the Channel Islands, but these two species are more common in offshore waters near there. Similarly a few Dall's porpoises have stranded on San Miguel Island in recent years and small numbers occur year-round near Santa Cruz and Santa Rosa islands. Risso's, bottlenose, and northern right whale dolphins are occasionally seen near the other Channel Islands during the seasons when these species are present in offshore waters, as are killer, pilot, and sperm whales. Section 3.7.2.1 "Sea Range" describes the seasonal distribution, numbers, and life history of each species in offshore waters where they are more abundant.

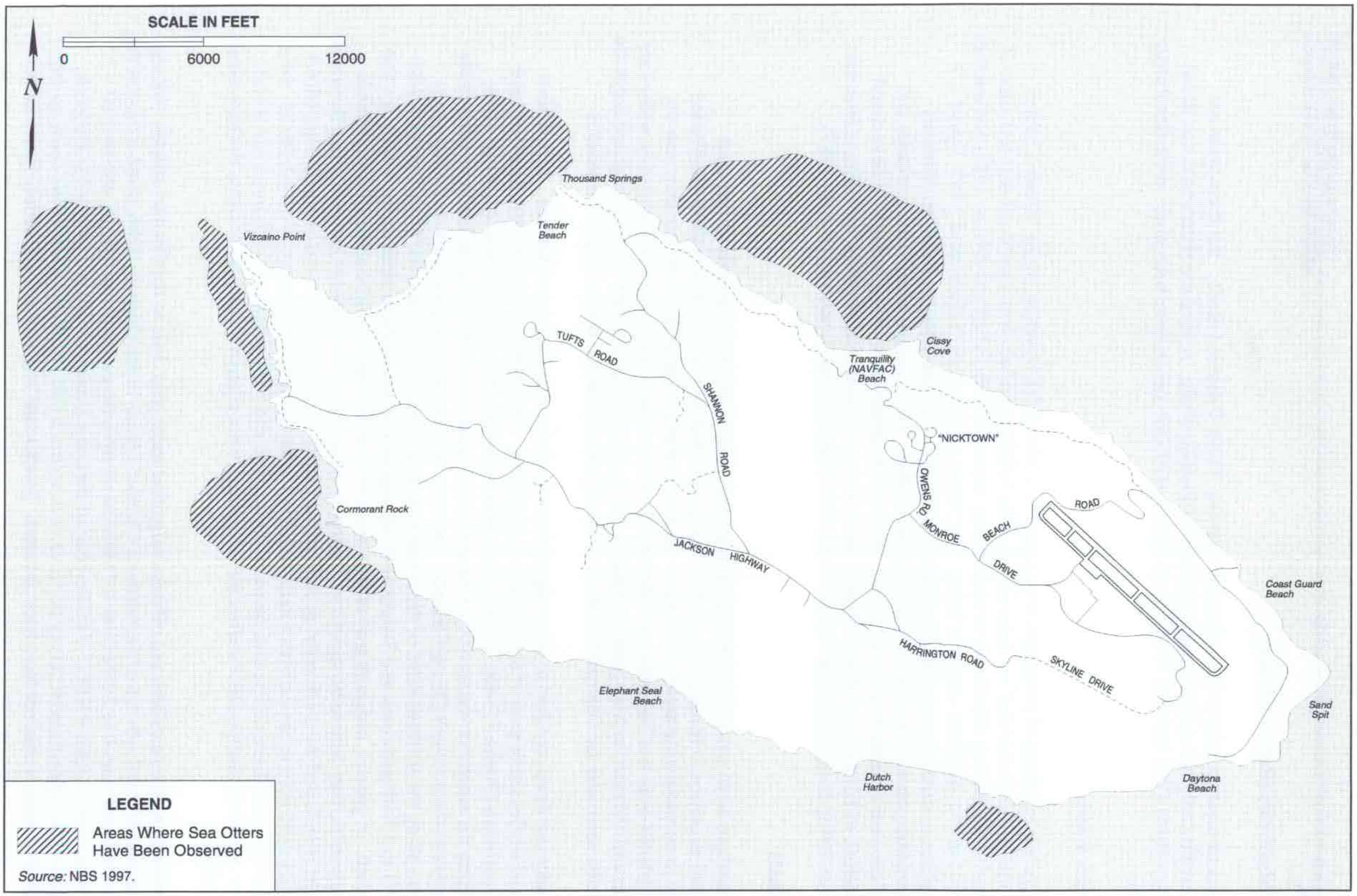


Figure 3.7-92
Sea Otter Distribution at San Nicolas Island

3.7.5.2 Mysticetes (Baleen Whales)

Six species of mysticetes have been recorded near the "Other Channel Islands," but these areas are heavily used by only two species, the gray whale and minke whale. A northern right whale was found stranded on Santa Cruz Island in 1916, but no sightings of that species have been made in the Sea Range since then.

Humpback Whale

There were two sightings of humpback whales within 3 NM (5.6 kilometers) of the "Other Channel Islands" during the studies that we summarized. One humpback whale was sighted off the west coast of San Miguel Island during ship-based surveys during September 1991 (Hill and Barlow 1992) and another was sighted off the southeast corner of Santa Cruz Island in July of 1975 (Dohl et al. 1983; Figure 3.7-48). In addition, shore observers at San Miguel Island have reported frequent sightings of mostly northbound humpbacks from late June through September. These groups often include females and young-of-the-year (Leatherwood et al. 1987). Since 1978, observers working in the SCB have noted concentrations of humpbacks off San Miguel, Santa Rosa, and Santa Cruz islands, including at least one occurrence during each season near Adams Cove, San Miguel Island (Leatherwood et al. 1987).

Gray Whale

In the nearshore areas around the Channel Islands, gray whales are seen primarily during their northbound migration to feeding areas in the Bering and Chukchi seas and during their southbound migration to overwintering areas off Mexico. Southbound migrating gray whales are seen near the Channel Islands from late December to February (peak in January) and northbound migrating whales are seen from mid-February to May (peak in March). However, gray whales that have not migrated north are occasionally seen near the Channel Islands at times of year outside the normal migration seasons.

Gray whales use three corridors as they migrate between Point Conception and Mexico. The relative numbers of whales using each of the corridors is unknown. Two of these corridors, the nearshore and offshore corridors (Figure 3.7-46), include the nearshore waters of the Channel Islands. Most of the whales using the nearshore waters of the Channel Islands pass west of San Miguel Island or through the passes between the northern Channel Islands. Far more whales pass along the western and southern coasts than along the northern sides of these four islands (Leatherwood et al. 1987), but Figures 3.7-82 and 3.7-93 to 3.7-95 and Jones and Swartz (1987a) suggest that the northern sides of the islands are also heavily used. In general, although gray whales are widely distributed throughout the Channel Islands during migration, they tend to be sighted in clusters in areas such as the channel between Santa Rosa and Santa Cruz islands and the south coast of Santa Cruz Island. In the waters around Santa Barbara Island, gray whales were seen in the extensive kelp beds around the north and west sides of the island, but were absent from the east shore during mid-January during 1986 and 1987 (Figure 3.7-96; Jones and Swartz 1987 a,b). However, during other studies most sightings were along the east side of Santa Barbara Island (Figure 3.7-82).

Gray whales using the nearshore and offshore migration route pass close to the Channel Islands. During special nearshore aerial surveys of the northern Channel Islands in mid-January 1986, about a third of the whales were found from 0 to 2 NM (0 to 3.7 kilometers) from the coasts of the islands, and over 80 percent were found within 4 NM (7.4 kilometers) of the coast (Jones and Swartz 1987 a,b). However, virtually all of the special aerial survey coverage was within 5 NM (9.3 kilometers) of the coast, so any offshore movements would not have been detected. Southbound migrants were generally found farther

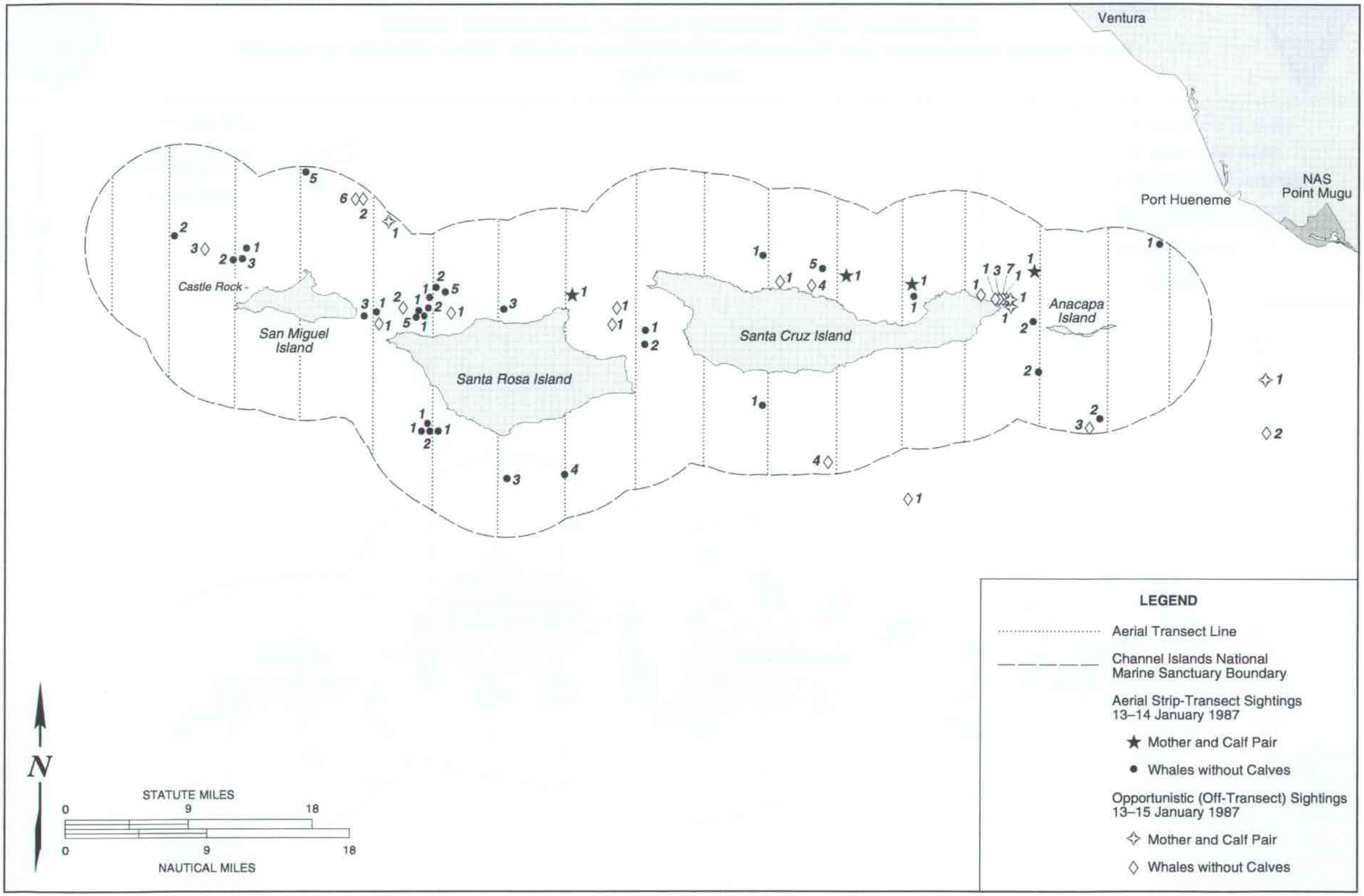


Figure 3.7-93
Location of opportunistic (off-transect) sightings of gray whales, 13-15 January 1987, and of sightings during aerial strip-transects of the northern islands in the Channel Islands National Marine Sanctuary, 13-14 January 1987. Numbers next to symbols indicate the number of whales in each sighting. From Jones and Swartz (1987a).

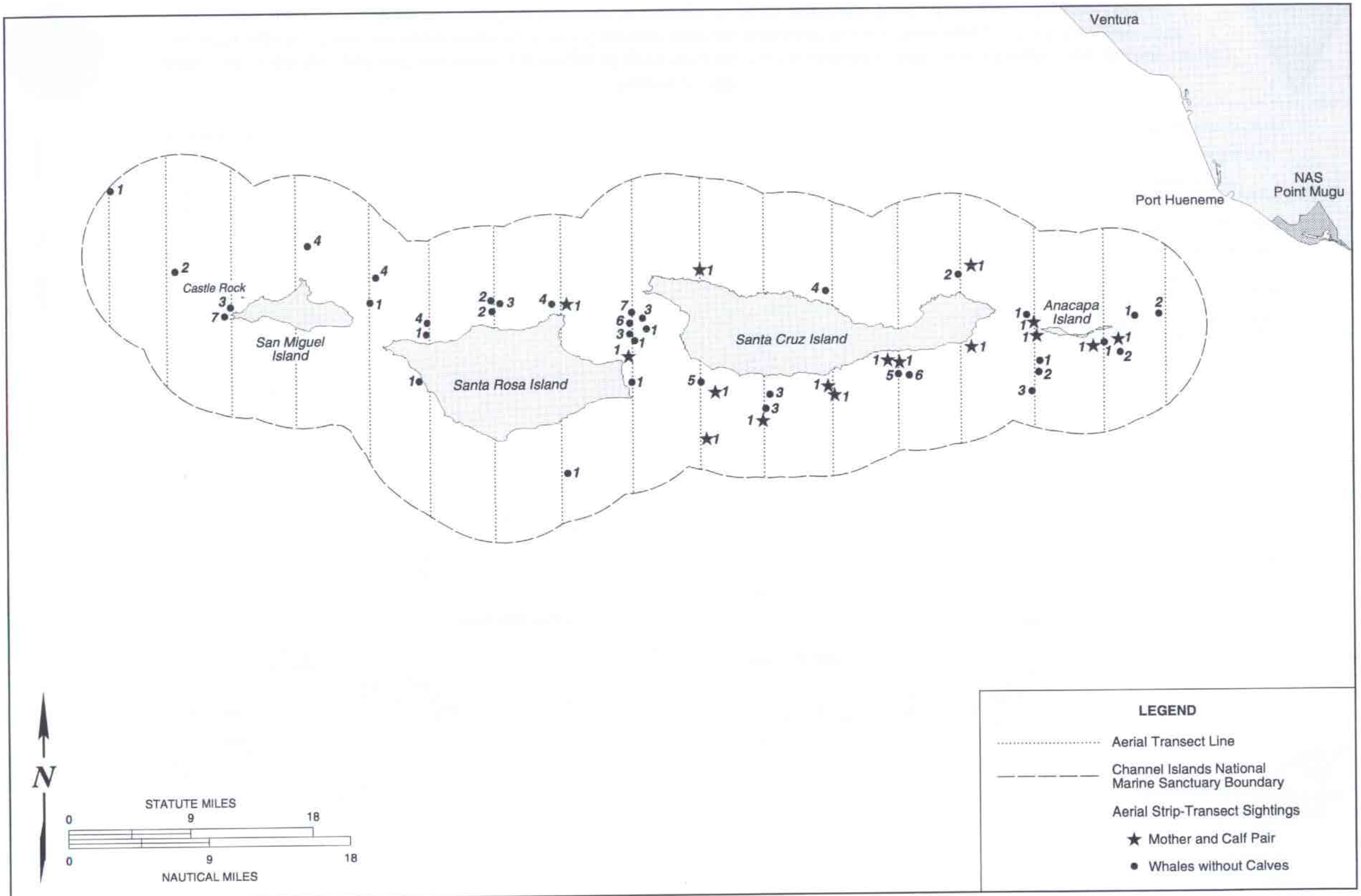


Figure 3.7-94
Location of sightings of gray whales during transects surveyed near the northern islands in the Channel Islands National Marine Sanctuary, 20-25 January 1986.
Numbers next to symbols indicate the number of whales in each sighting. From Jones and Swartz (1987b).

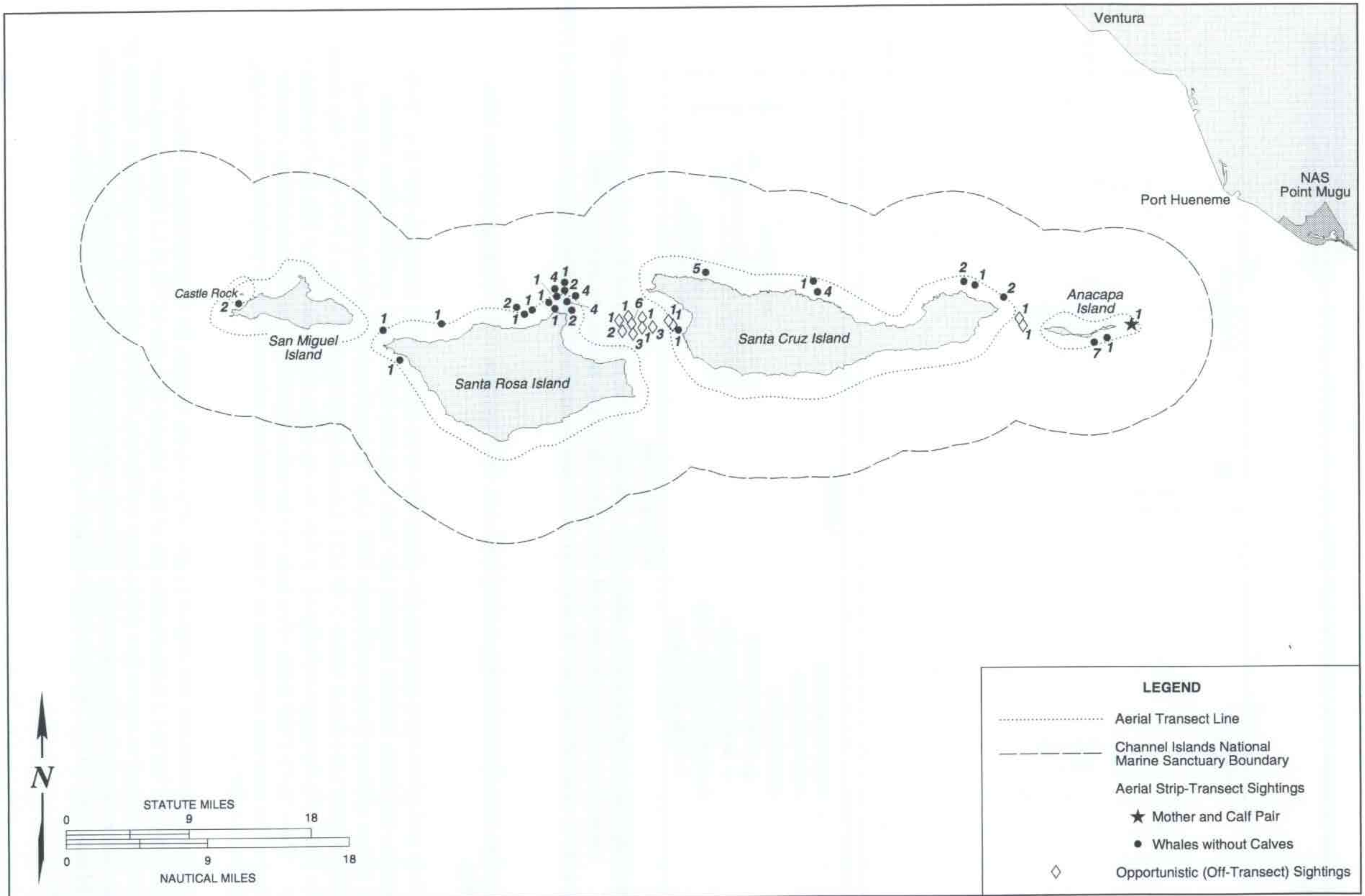


Figure 3.7-95
Location of sightings of gray whales during near-shore transects surveyed near the northern islands in the Channel Islands National Marine Sanctuary, 20, 22 and 24 January 1986. Numbers next to symbols indicate the number of whales in each sighting. From Jones and Swartz (1987b).

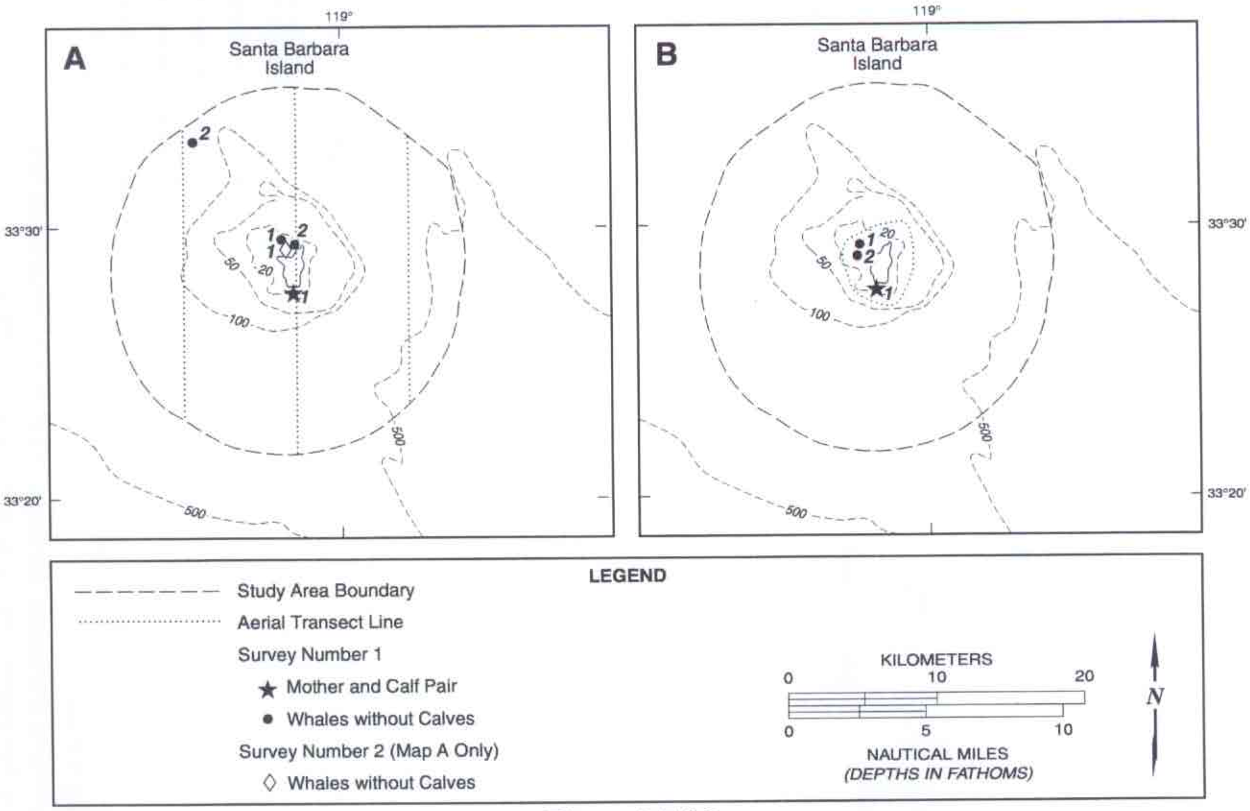


Figure 3.7-96
Location of sightings of gray whales during *(A)* transects surveyed 20 and 24 January 1986 and *(B)* near-shore transects surveyed near Santa Barbara Island, 20 January 1986. Numbers next to symbols indicate the number of whales in each sighting. From Jones and Swartz (1987b).

from shore than were those returning north (Dohl et al. 1983; Braham 1984; Herzing and Mate 1984; Poole 1984).

Most mothers and calves were seen near the islands that were closest to the mainland coast (i.e., Santa Cruz, Anacapa, and Santa Barbara islands); few were seen near San Miguel and Santa Rosa islands, which are farther offshore (Jones and Swartz 1987 a,b). Most (94 percent) of the mothers and calves seen near the islands were found within 3 NM (5.6 kilometers) of shore (Figures 3.7-93 to 3.7-96) (Jones and Swartz 1987 a,b), but again virtually all of their survey effort was closer than 5 NM (9.3 kilometers) from shore. These mother/calf pairs often were not actively migrating. Resting and milling comprised about a third of the activities performed by mothers and calves, and some calves probably were nursing (Jones and Swartz 1987a).

Radio-tagging studies indicate that migrating gray whales pass through the Channel Islands National Marine Sanctuary (6 NM [11.1 kilometers] north of San Miguel Island to 6 NM [11.1 kilometers] south of Santa Barbara Island) in one to four days (Jones and Swartz 1987b). Although a significant fraction of the 21,100 eastern North Pacific gray whales follow the nearshore and offshore migration routes past the Channel Islands, only 613 to 756 have been estimated to be present at one time (Jones and Swartz 1987 a,b).

Blue Whale

Three sightings of blue whales have been made within 3 NM (5.6 kilometers) of the coasts of the "Other Channel Islands" during the studies that we summarized here. Sightings of two and three animals were made south of San Miguel Island during September 1975 and October 1976, respectively, and a sighting of two whales was made south of Santa Barbara Island during June 1977 (Figure 3.7-49). In addition, several sightings were made 3 to 10 NM (5.6 to 18.5 kilometers) north and northwest of San Miguel Island, primarily during summer.

Other researchers have also seen blue whales, thought to be the same individuals, around San Miguel Island for a month or more during summer and early autumn (Leatherwood et al. 1987). They have also sighted them within 0.11 NM (200 meters) of Castle Rock, a small island northwest of San Miguel Island, in October (Leatherwood et al. 1987). Blue whale use of the northwestern Channel Islands area may have increased in recent years.

Fin Whale

During the studies summarized and mapped here, one sighting of two fin whales was made within 3 NM (5.6 kilometers) of Santa Barbara Island during September, and a sighting of two fin whales was 5 NM (9.3 kilometers) north of San Miguel Island, also in summer. However, most fin whales are seen in offshore waters (Figure 3.7-50).

Other researchers have also sighted fin whales near the "Other Channel Islands" during summer. Spring and early summer sightings have been made in the Santa Barbara Channel, at four locations along the southwest side of Santa Cruz Island, and at two locations off the southwest side of Santa Rosa Island (Leatherwood et al. 1987). In winter, fin whales are found principally offshore and are less common in the Channel Islands.

Minke Whale

Off the coast of California, the minke whale is found primarily over the continental shelf. Evidence suggests that most minke whales utilizing the Sea Range and offshore waters of the Channel Islands move either into offshore waters or south of this area during autumn and winter (Section 3.7.2.2). Minke whales return to the southeastern part of the Sea Range, including the waters around the Channel Islands, during spring and summer. However, a few minke whales are seen in offshore waters near the Channel Islands at all times of the year.

The summer population has a distribution that includes the western Santa Barbara Channel; the undersea ridge that extends between Santa Rosa and San Nicolas islands; the coastal shelves south of San Miguel, Santa Rosa, and Santa Cruz islands; and the east side of San Nicolas Island (Bonnell and Dailey 1993; Section 3.7.2.2). Minke whales are also seen near Anacapa Island and southward over the eastern rim of Santa Cruz Basin. During the summer, a significant fraction of the approximately 180 animals that inhabit waters off California would be found in the areas described above.

3.7.5.3 Pinnipeds

Harbor seals are present on all of the Channel Islands in the range, as well as on Santa Barbara Island near the range (Table 3.7-10). The numbers of harbor seals shown in Table 3.7-10 represent aerial survey counts of animals hauled out at the time of the survey. Counts include animals of all ages and

Table 3.7-10. Indices of abundance of pinnipeds that might be encountered in the Point Mugu Sea Range. The given numbers are from counts during the indicated year. For each species, the most recent year with counts from all known haul-out sites is given. In many cases, higher numbers were present in other years. Because not all animals are hauled out at one time, even peak counts underestimate the total number of animals using each site each year.

	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara	San Nicolas
Harbor seal -all ages (1994)[a]	1,040	868	1,147	285	29	457
Elephant seal (1995)						
- pups[b,c]	13,462[c]	186[c]	Unknown [g]	Unknown [g]	44[b]	6,575[c]
- adults & subadults[b,c]	16,020[c]	246[c]	Unknown [g]	Unknown [g]	61[c]	6,983[c]
California sea lion pups (1990)[d]	13,023	0	Unknown [g]	Unknown [g]	1,286	11,766[h,i]
Northern fur seal pups (1995)[e]	2,509	0	0	0	0	0
Steller sea lion[f]	Formerly	0	0	0	0	0
Guadalupe fur seal[f]	Occasional	0	0	0	Rare	0

[a] Aerial photos, Beeson and Hanan (1994); [b] ground counts, Lowry et al. (1996); [c] aerial photos, Lowry et al. (1996); [d] ground counts, Lowry et al. (1992a); [e] Barlow et al. (1997); [f] ground counts, Stewart et al. (1993); [g] DeMaster et al. (1984), mention presence; [h] aerial photos, Lowry et al. (1992a); [i] counts of 16,889 pups and 16,020 adults and subadults are available for San Nicolas Island for 1994 (Lowry n.d.). 1994 data are not available for the other islands.

both sexes. Populations of harbor seals were relatively stable on all of the "Other Channel Islands" except for Santa Cruz Island between 1982 and 1995. Population growth rates were near zero (-1.15 to +0.05 percent) for San Miguel, Santa Rosa, Anacapa, and Santa Barbara islands. However, Santa Cruz Island had a mean annual population growth of 5.7 percent (Hanan 1996). Harbor seal populations in most other parts of California are increasing (see Section 3.7.2.3, "Harbor Seal"). The populations on several of the Channel Islands may be constrained by interspecific competition with northern elephant seals for haul-out sites.

Two thirds of the California stock of northern elephant seals breed and pup on San Miguel Island. Elephant seals also breed and pup in small numbers on Santa Rosa and Santa Barbara islands (Lowry et al. 1996; Table 3.7-10). Small numbers have been reported on Santa Cruz and Anacapa islands (DeMaster et al. 1984).

In 1990 the largest colony of California sea lions in California was found on San Miguel Island, but now the San Nicolas Island colony may be larger. Small numbers are also found on Santa Barbara Island (Table 3.7-10; Lowry et al. 1992b).

Steller sea lions were historically present on San Miguel Island, but have not been sighted there since 1983. Guadalupe fur seals are occasional visitors there. San Miguel Island and the adjacent Castle Rock have the only rookery of northern fur seals in the region.

The following subsections provide additional details concerning pinniped use of each of these islands.

San Miguel Island

San Miguel Island, the northwesternmost of the Channel Islands, is located 61 NM (113 kilometers) west of NAS Point Mugu. It provides haul-out sites for large rookeries of California sea lions and northern elephant seals, for small rookeries of northern fur seals, and for harbor seals (Table 3.7-10).

Harbor Seal

Harbor seals have been found around most of the island, except on the western tip (DeMaster et al. 1984). Numbers increased greatly from the early 1950s to the early 1980s, with an average annual increase of 22 percent from 1958 to 1976 (Figure 3.7-97). From 1982 to 1995, the harbor seal population on San Miguel Island has declined slightly at a mean rate of 1.15 percent per year (Hanan 1996). As mentioned above, this decline may be due to interspecific competition for terrestrial sites with northern elephant seals.

Northern Elephant Seal

San Miguel Island is extremely important to northern elephant seals; two thirds of the California stock hauls out on San Miguel Island to have their pups, breed, and molt. The general biology, seasonal distribution, and movements of northern elephant seals through the Sea Range are described in Section 3.7.2.3 and their activities while hauled out on land are described in Section 3.7.4.3; that information is not repeated here.

Northern elephant seals haul out all along the south coast and along most of the northwest coast of San Miguel Island (Figure 3.7-98). Occupation of the latter areas began in 1988 (Lowry et al. 1992b). The number of births increased by an average of 14 percent annually from 1964 to 1981, by 10 percent

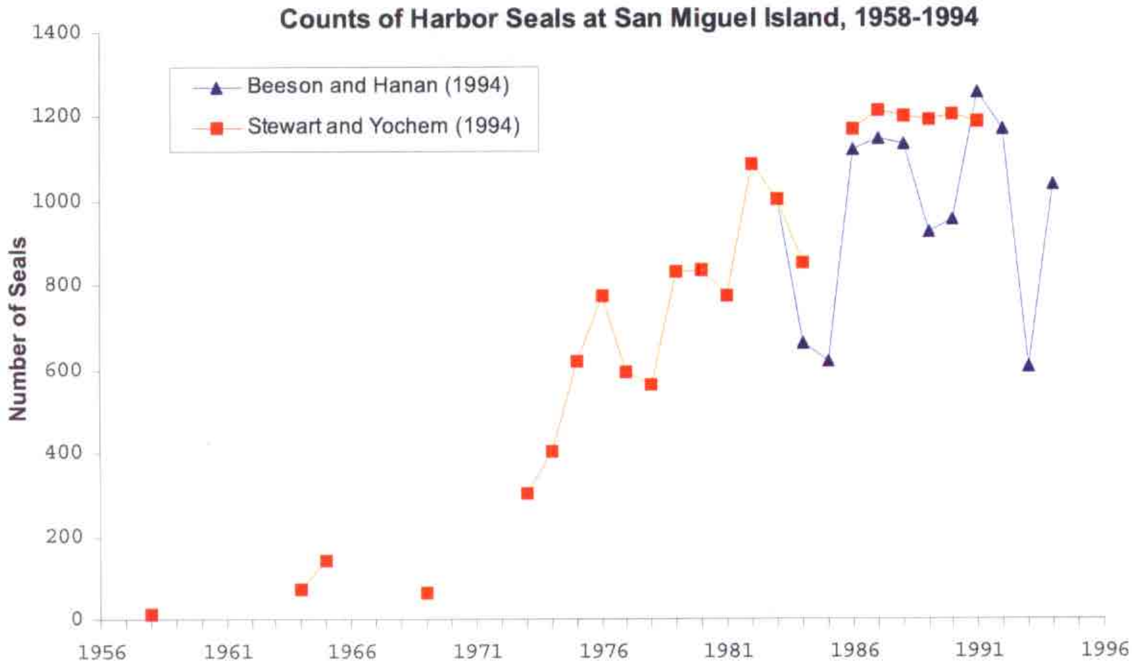


Figure 3.7-97
Counts of harbor seals at San Miguel Island, 1958-94.
Aerial counts were conducted by Beeson and Hanan (1994) and ground counts by Stewart and Yochem (1994).

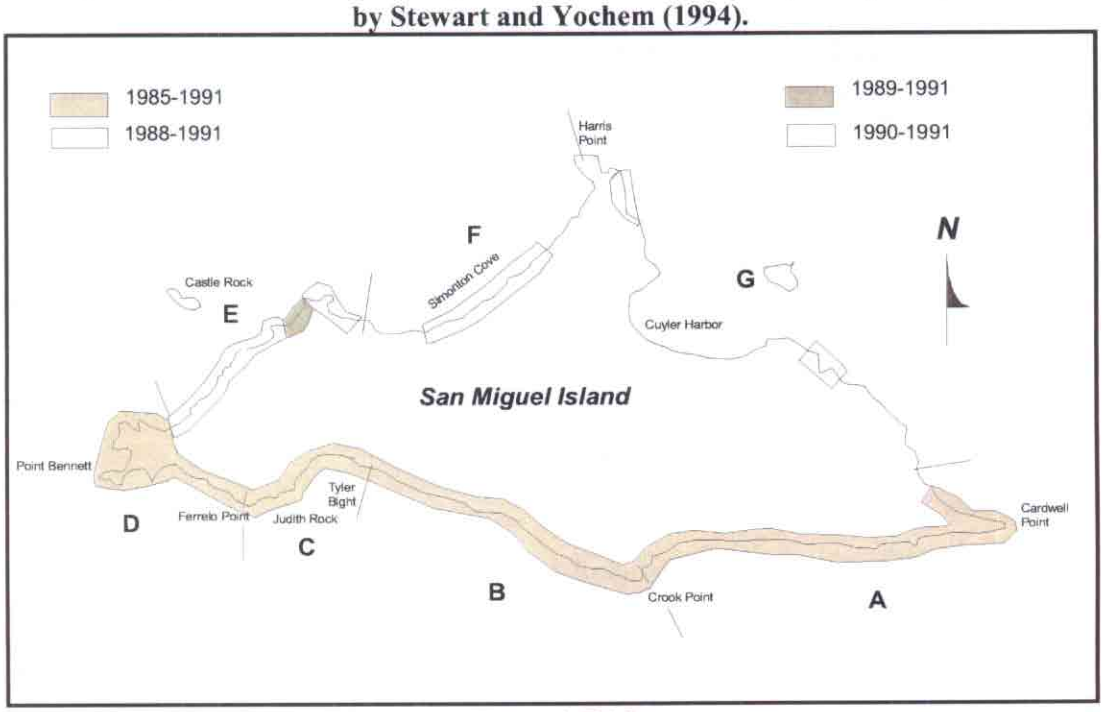


Figure 3.7-98
Map of San Miguel Island showing shaded areas where northern elephant seals were photographed and area codes used to document counts in specific areas of the island. From Lowry et al. (1992).

annually from 1981 to 1985 (Stewart et al. 1993, Figure 3.7-99), and by 4.0 percent annually from 1986 to 1995.

California Sea Lion

California sea lions are found along the southwest coast of San Miguel Island and at Castle Rock adjacent to San Miguel (Figure 3.7-100; Lowry et al. 1992b). Most are found on Point Bennett and the coast immediately north of there (Table 3.7-11; Figure 3.7-100). California sea lion births have increased on San Miguel Island since counts were started in 1971 (Figure 3.7-101), but the rate of increase during 1983 to 1990 (10.8 percent annually) has been lower there than at San Nicolas Island (21.2 percent annually) – the other major haul-out area. In 1990, 49 percent of the U.S. stock was associated with San Miguel Island. Based on the 1995 estimate of the size of the U.S. stock, 81,800 to 92,100 California sea lions use the coast of San Miguel Island to haul out, breed, and give birth to pups. As the population has continued to increase, the areas used have expanded and new haul-out areas have been used (Figure 3.7-100).

Northern Fur Seal

Northern fur seal colonies are found at Adams Cove on Point Bennett, and also at nearby Castle Rock (Figure 3.7-100). These are the only northern fur seal colonies found in California. Based on counts of pups in 1995, the population associated with these haul-out sites is estimated to be approximately 10,000 animals and has increased dramatically in recent years (Figure 3.7-73). These colonies are occupied from early May to late November with different age and sex classes being present at different times (Figure 3.7-53). Adult males are the first animals to arrive; upon arrival they establish territories which they defend from other males. Females arrive several weeks later and give birth within one to two days of their arrival. After nursing their pups for an average of 8.3 days, the females alternate between periods of 6.9 (±1.4 SD) days at sea feeding and 2.1 (±0.3 SD) days nursing. Pups are weaned at four to five months of age and go to sea immediately (Antonelis et al. 1990). Adult males leave the haul-out sites in late July to early August and go to sea to feed until the following May. Juveniles and other non-breeding animals haul out from mid-August to early October to molt.

Guadalupe Fur Seal

There have been at least 25 sightings of Guadalupe fur seals at San Miguel Island since 1969; nearly all sightings were of subadult and adult males (Stewart et al. 1987). As mentioned for San Nicolas Island in Section 3.7.4.3, Guadalupe fur seals are able to compete for territories amidst California sea lions and they may recolonize San Miguel Island if numbers on Isla de Guadalupe continue to increase (Gallo-Reynoso 1994).

Santa Rosa Island

Harbor seals and northern elephant seals are present on Santa Rosa Island. Harbor seals are distributed around the coastline of Santa Rosa Island (DeMaster et al. 1984). Numbers increased from 1958 to 1981 (Figure 3.7-102). From 1982 to 1995 the population size has remained stable (mean annual increase was 0.02 percent, Hanan 1996).

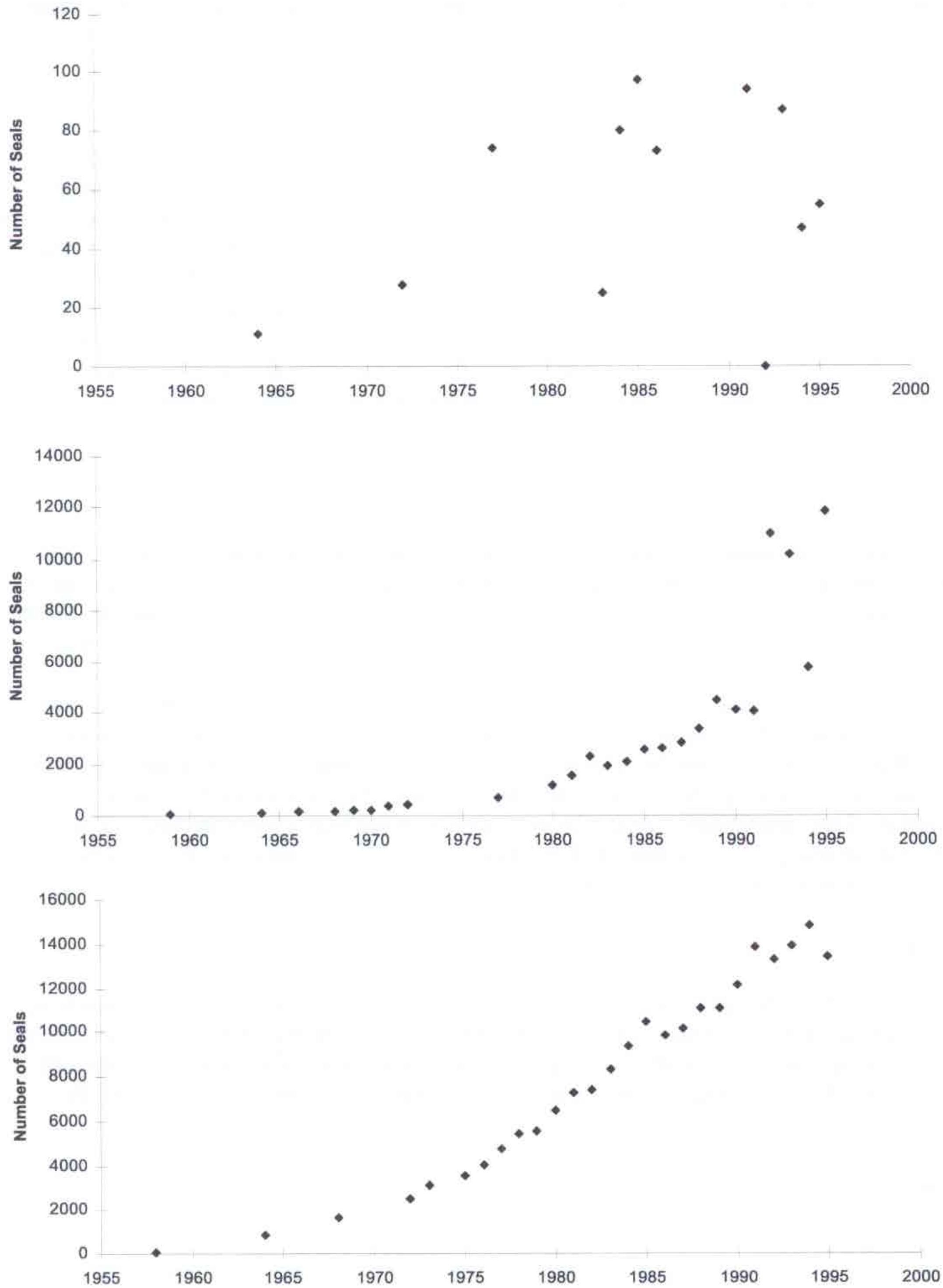


Figure 3.7-99
Northern elephant seal births on Santa Barbara Island (top panel), San Nicolas Island (middle panel), and San Miguel Island (bottom panel), 1958-95.
Plotted from Table 2.1 in Stewart et al. (1994) and Table 1 in Lowry et al. (1996).

Table 3.7-11. Counts of California sea lion pups from vertical aerial photographs taken at San Miguel Island, 1987-90. Figure 3.7-100 shows the locations of areas A to K. From Lowry and Perryman (1992).

Area	Area Code	Dates of California Sea Lion Pup Census Flights					
		June 28 1987	July 26 1987	July 24 1988	July 21 1989	July 18 1990	July 25 1990
Northeast Pt. To East Rocks	A	192	172	114	153	82	85
Northeast Pt.	B	725	773	668	903	492	578
Northwest Pt.	C	4,594	4,862	3,826	4,338	3,615	2,903
Northwest Pt. Rocks	D	33	139	67	94	64	50
Point Bennett	E	2,002	2,037	1,720	1,905	2,623	2,016
Point Bennett West Rock	F	24	42	39	46	26	22
South Cove	G	2,596	2,330	2,415	2,787	2,753	2,762
Cormorant Rock	H	253	350	269	317	265	245
Adams Cove	I	667	823	635	680	791	876
Little Cove to Tyler Bight	J	705	849	930	1,128	1,261	1,312
Castle Rock	K	361	430	372	349	231	217
Total		**12,152**	**12,807**	**11,055**	**12,700**	**12,203**	**11,066**

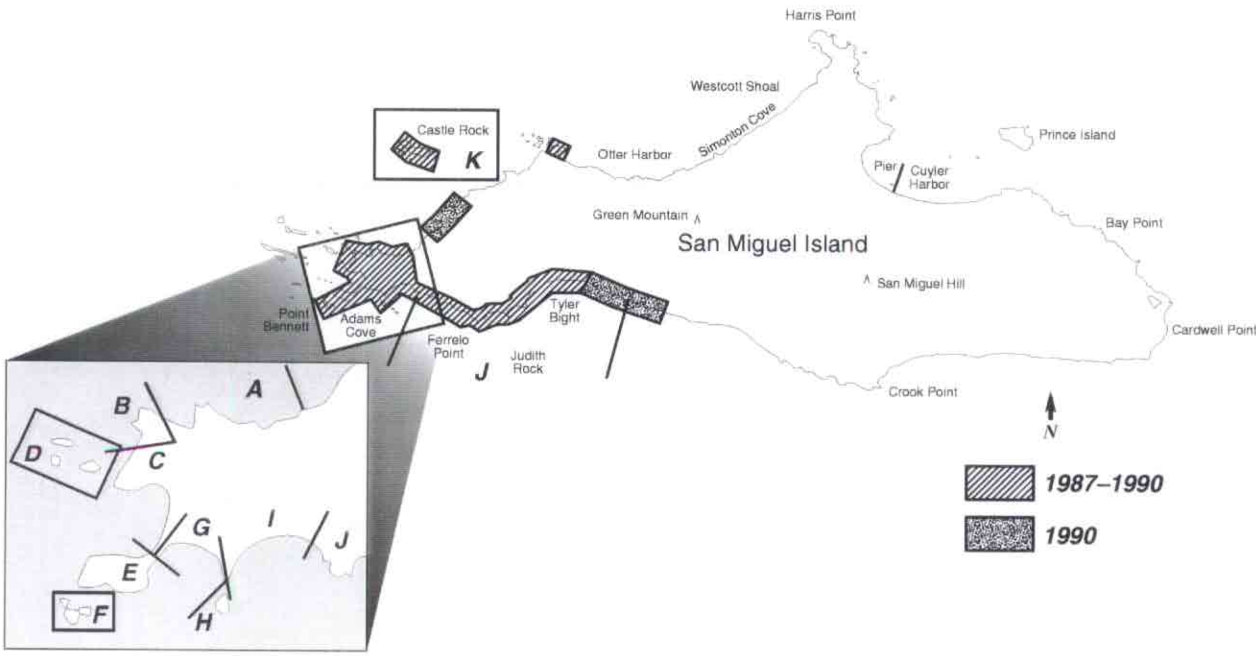


Figure 3.7-100
Map of San Miguel Island showing shaded areas where California sea lions were photographed and area codes used to document counts in specific areas of the island. (inset is map of Point Bennett hauling grounds). From Lowry and Perryman (1992).

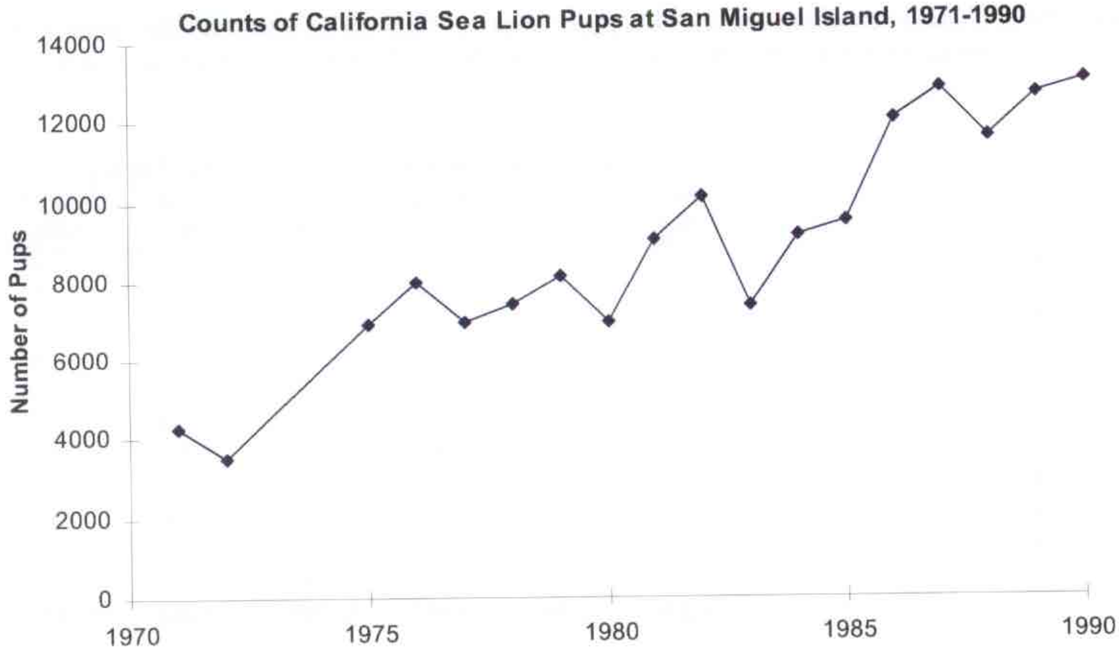


Figure 3.7-101
Counts of California sea lion pups at San Miguel Island, 1971-90.
Plotted from Table 1 in Lowry et al. (1992).

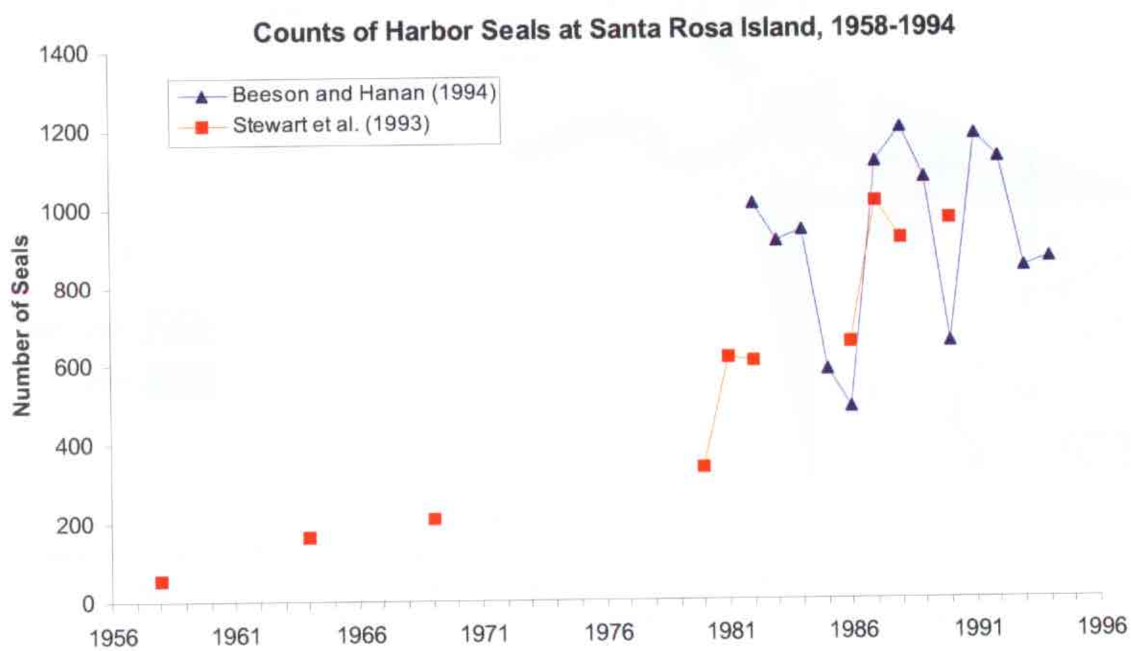


Figure 3.7-102
Counts of harbor seals at Santa Rosa Island, 1958-94.
Aerial counts were conducted by Beeson and Hanan (1994) and ground counts by Stewart et al. (1993).

In 1985, Stewart and Yochem (1986) observed two northern elephant seal pups and two females at the southwestern tip of Santa Rosa Island. Since then, numbers of pups born there have increased substantially. In 1994 and 1995, 315 and 186 pups, respectively, were counted there (Lowry et al. 1996). The rapid rate of increase is at least partially due to immigration of females from other rookeries.

Santa Cruz Island

Harbor seal haul-out sites are distributed all around the coastline of Santa Cruz Island (DeMaster et al. 1984). As on the other Channel Islands, the Santa Cruz population increased dramatically from 1958 to 1981 (Figure 3.7-103). However, unlike the situation on the other islands, the population has continued to grow at a rate of 5.7 percent annually from 1982 to 1995 (Hanan 1996). Based on a single photographic count, 1,147 harbor seals were hauled out on Santa Cruz Island in 1994 near the peak period of haul out (Beeson and Hanan 1994).

DeMaster et al. (1984) report that California sea lions and northern elephant seals have been seen on Santa Cruz Island. Breeding or pupping has not been documented there for either species. The use of Santa Cruz Island by California sea lions and northern elephant seals is probably sporadic.

Anacapa Island

Harbor seals regularly haul out and pup in small numbers on Anacapa islands (three distinct islets comprise Anacapa Island proper). California sea lions and northern elephant seals occasionally haul out there but no pupping has been observed (DeMaster et al. 1984).

Harbor seals haul out in small numbers at all three of the Anacapa islands (DeMaster et al. 1984; Hanan et al. 1992). There was an increase in the harbor seal population there from 1958 to 1981, but the increase was not as dramatic as at San Miguel and Santa Cruz islands. Since 1982 the population has remained relatively stable (mean annual increase was 0.05 percent, Hanan 1996; Figure 3.7-104). A total of 285 harbor seals were counted there during a single photographic survey in 1994 (Beeson and Hanan 1994).

Santa Barbara Island

Santa Barbara Island is along the edge of the Sea Range but is not actually within it. Moderate numbers of California sea lions and small numbers of harbor and northern elephant seals occur here.

Harbor Seal

Very few harbor seals haul out at Santa Barbara Island, and no pupping is thought to occur there (Hanan et al. 1992). The counts have been variable and have ranged from 0 to 35 seals. The most recent count was 29 in 1994.

Northern Elephant Seal

Small numbers of northern elephant seal pups have been born on Santa Barbara Island in recent years. From 1984 to 1991, 69 to 106 pups were born there annually, but in 1993 to 1995 (the last years with published census data), only 44 to 53 pups were born annually.

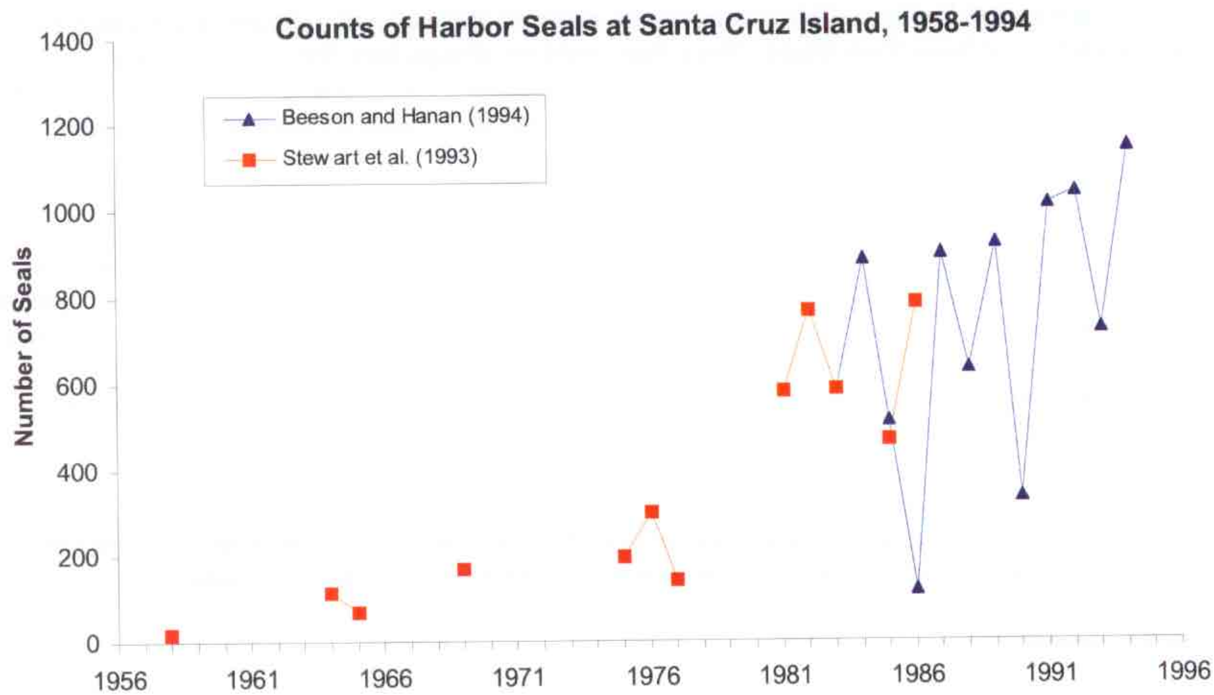


Figure 3.7-103
Counts of harbor seals at Santa Cruz Island, 1958-94.
Aerial counts were conducted by Beeson and Hanan (1994)
and ground counts by Stewart et al. (1993).

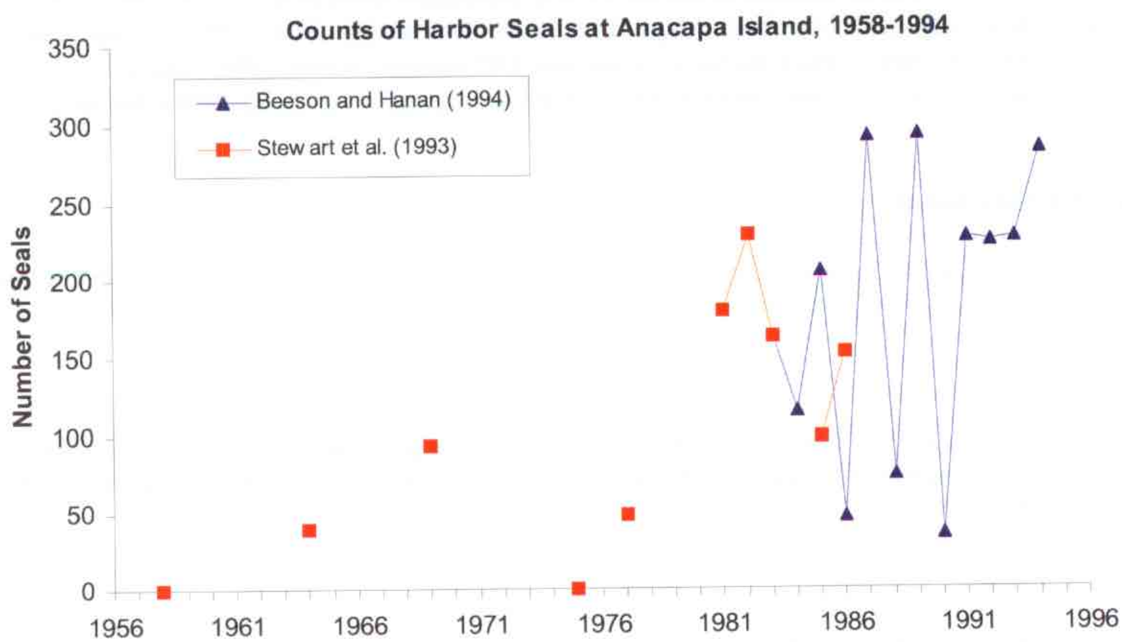


Figure 3.7-104
Counts of harbor seals at Anacapa Island, 1958-94.
Aerial counts were conducted by Beeson and Hanan (1994)
and ground counts by Stewart et al. (1993).

California Sea Lion

Moderate numbers of California sea lions haul out and give birth to pups on Santa Barbara Island. The population has doubled since counts were initiated in 1975 (Figure 3.7-105). In 1990, 1,286 pups were counted, suggesting a total population of 5,700 to 6,400.

3.7.5.4 Sea Otter

In 1990, a group of 10 sea otters was found near Point Bennett on San Miguel Island. These may have been animals that had been translocated to San Nicolas Island, but had left there (USFWS 1996). Gallo-Reynoso and Rathbun (1997) noted several recent sightings of sea otters in Mexico. They believed that these recent Mexican sightings were of animals that had dispersed from San Nicolas Island. However, there were occasional sightings of sea otters in the Channel Island from 1953 to 1974 (Leatherwood et al. 1978), long before the translocation to San Nicolas Island was started in 1987. From 1990 to 1993, 14 sea otters were captured on San Miguel Island and relocated to the mainland population, as called for under the provisions of the "no otter" zone (see Section 3.7.2.4). The most recent survey indicated that at least two sea otters were still present at San Miguel Island (USFWS 1996).

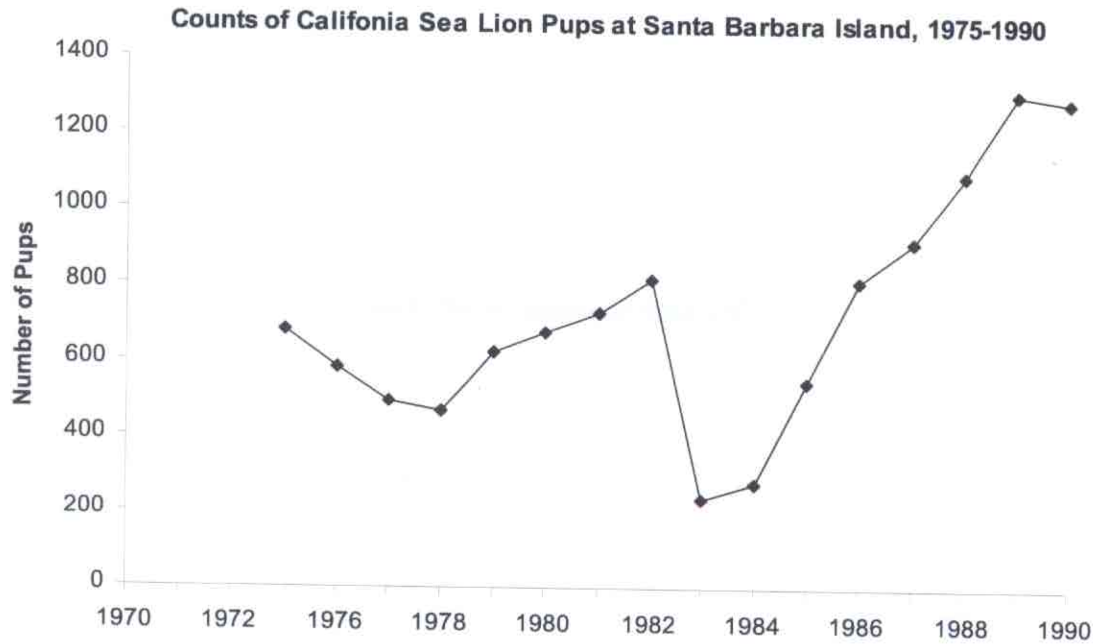


Figure 3.7-105
Counts of California sea lion pups at Santa Barbara Island, 1971-90.
Plotted from Table 1 in Lowry et al. (1992).

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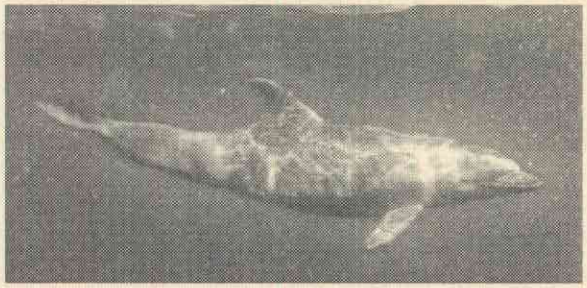
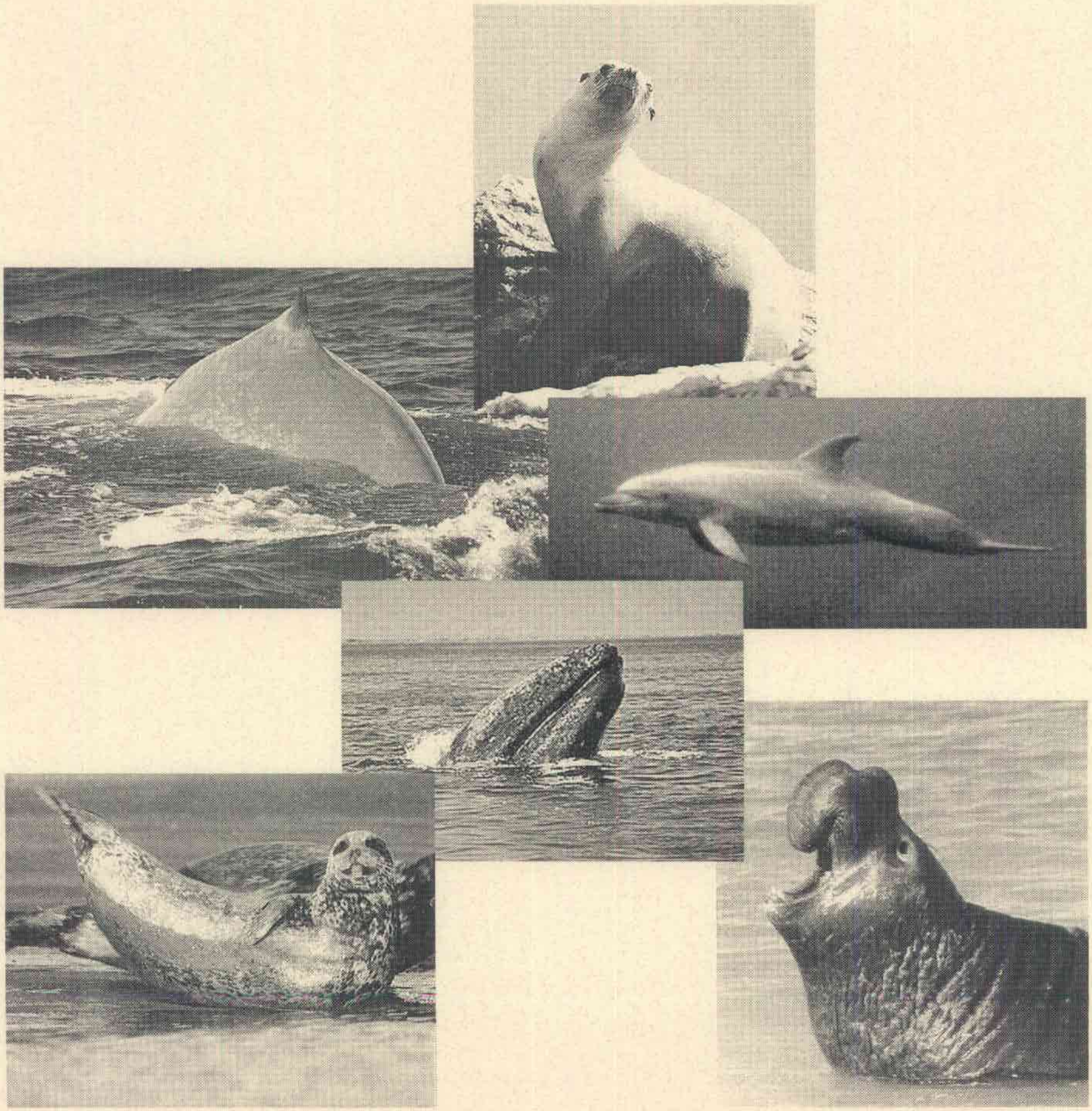


Affected Environment References



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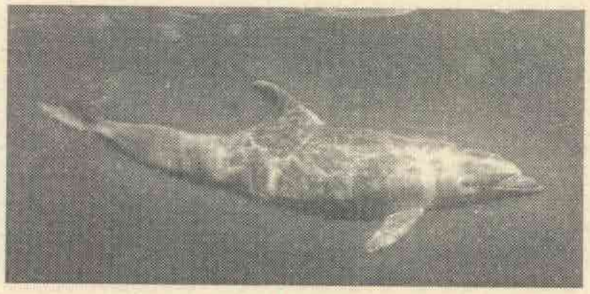
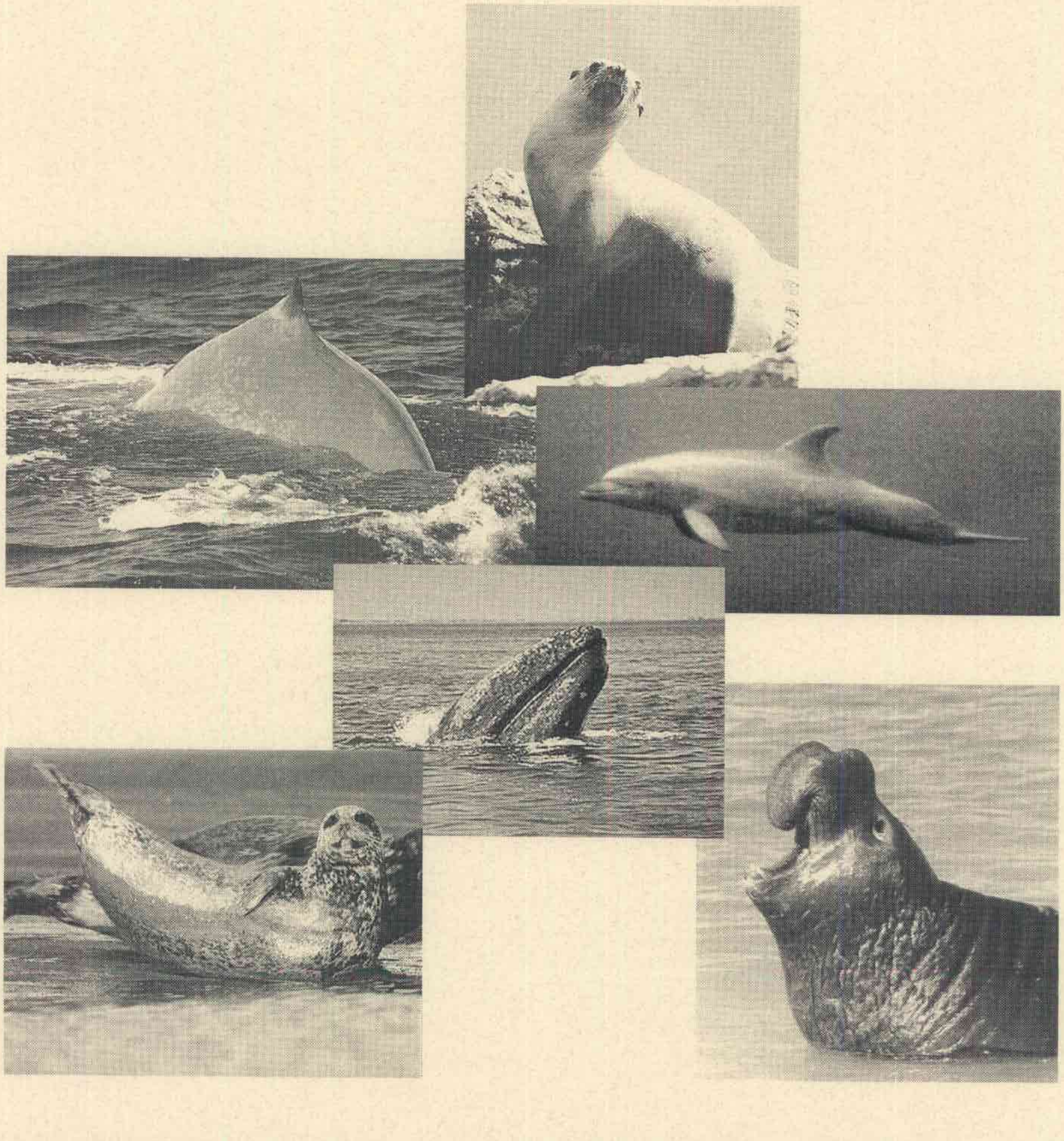


4.7 Biological Consequences for Marine Mammals



Point Mugu Sea Range
Marine Mammal Technical Report:

Biological Consequences for Marine Mammals

by

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EXECUTIVE SUMMARY: BIOLOGICAL CONSEQUENCES FOR MARINE MAMMALS

The No Action Alternative consists of continuation of the following current operations: air-to-air, air-to-surface, surface-to-air, surface-to-surface, and subsurface-to-surface operations, along with four littoral warfare training exercises and two Fleet Exercises per year. The Minimum Requirement Alternative and the Preferred Alternative would each include current operations plus differing numbers of additional operations.

Most of the current military operations on the Sea Range do not cause biologically significant effects on marine mammals. In particular, subsonic and supersonic overflights of marine mammals at sea by aircraft, missiles, and targets are not believed to cause more than momentary reactions that have no effect on the well-being of individual marine mammals or their populations. However, stronger and/or more prolonged disturbance incidents occasionally occur. Small numbers of marine mammals may be injured or killed, mainly by disturbance-induced stampedes of pinnipeds from beaches. However, stampede-related injuries or deaths have not been documented on the Sea Range as a result of military activities. Although current operations have some adverse effects on a few individual marine mammals on the Sea Range, impacts on marine mammal populations are less than significant.

With current operations, about 0.002 marine mammals per year (i.e., one individual in 500 years) may be injured or killed by missiles and debris hitting the water. The number of marine mammals struck by Close-In Weapon System (CIWS) rounds during current operations approaches zero (4.0×10^{-6} animals/year). Intact missiles hitting the water generate a shock wave close to the impact site and a strong sound pulse out to a somewhat longer distance. Based on provisional criteria for the occurrence of Temporary Threshold Shift (TTS), approximately four marine mammals per year might experience mild TTS as a result of these impacts. About 0.02 seals may experience mild TTS as a result of the in-air noise of CIWS gun firing if they have their heads above water. Marine mammals exposed to noise from low-flying Vandal targets will not experience TTS. There is only a small probability (0.063 marine mammals per year) that a member of a threatened or endangered species might incur mild TTS.

The effects of the Minimum Requirement Alternative and the Preferred Alternative on marine mammals are both predicted to be less than significant as well. Each of these alternatives would include current operations plus differing numbers of additional operations. Both of these alternatives would result in slight increases in the number of disturbance incidents, and in the potential for injury or deaths of a few marine mammals on the beaches or at sea. The overall impact on marine mammal populations would remain less than significant.

Under the Minimum Requirement or Preferred alternatives (including current operations), the number of marine mammals injured or killed by missiles or debris hitting the water is expected to increase to 0.0038 or 0.0041 per year, respectively, from the present 0.002. The number of marine mammals that might experience mild TTS is expected to increase to 7.5 or 8.1 per year, respectively, from the present four.

Pinnipeds on San Nicolas Island are exposed to strong noise of short duration during target launches. These animals apparently tolerate the sounds, although few specific data on behavior during launches are available. Northern elephant seal and California sea lion populations near the launch sites and around the entire island are expanding. Impacts of current operations on the pinniped populations on San Nicolas Island are less than significant. Impacts of planned operations under the Minimum Requirement and Preferred alternatives are also expected to be less than significant.

Harbor seals at NAS Point Mugu are not exposed to sound levels that could cause disturbance and would not be exposed to these kinds of levels under the Minimum Requirement or Preferred alternatives. Impacts on seals at NAWCWPNS Point Mugu are less than significant.

4.7 MARINE MAMMALS

This document constitutes the "Environmental Consequences" section of the "Marine Mammal Technical Report" for the Point Mugu Sea Range Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). This document contains the detailed rationale and analysis that form the basis for the briefer version presented in Section 4.7 of the EIS/OEIS. The Technical Report includes a more comprehensive review of the relevant literature and issues, and more detailed descriptions of the analyses on which the impact predictions are based. This "Marine Mammal Technical Report" is incorporated by reference into the EIS/OEIS.

This Technical Report describes the potential impacts on marine mammals of current and proposed Sea Range operations. It is organized in a sequence similar to Section 4.7 of the EIS/OEIS. Section 4.7.1 focuses on the approach used to assess impacts on marine mammals, including a review of potential effects of phenomena common to many test and training operations on the Sea Range. These common phenomena include exposure to impulsive noise; aircraft and missile overflights; vessel traffic; missiles, bullets, or debris striking the surface of the water; and other debris-related issues such as entanglement and release of hazardous constituents. The next section, 4.7.2 No Action Alternative, evaluates the impacts of current Sea Range operations. Sections 4.7.3 Minimum Requirement Alternative and 4.7.4 Preferred Alternative then evaluate the impacts of current operations plus the additional operations envisaged under those two alternatives, relying on Section 4.7.1 and 4.7.2 for documentation of the impacts of current Sea Range activities included within those alternatives.

This analysis concerns the effects on marine mammals of the military activities managed by the Naval Air Warfare Center, Weapons Division (NAWCWPNS), Point Mugu, and conducted on the Point Mugu Sea Range. Many human activities aside from those of NAWCWPNS occur on the Sea Range. The Sea Range is open to commercial and other vessel and aircraft traffic. Some other military activities, primarily involving ships and submarines, also occur on the Sea Range. Missiles launched from Vandenberg Air Force Base pass over the Sea Range. Civil activities and military activities other than those of NAWCWPNS Point Mugu are not addressed directly in this document. Also, this analysis specifically excludes certain past, present, or (potential) future Navy actions whose environmental effects have been or would be analyzed separately. In particular, this analysis does not deal with the possibility of underwater explosions of any type, torpedo tests, sonobuoy tests, or use of sonar on the Sea Range, nor does it deal with barge traffic to San Nicolas Island.

4.7.1 Approach and Background Information

Potential effects of Navy activities on marine mammals include acoustic and non-acoustic effects. Possible acoustic effects include behavioral disturbance (including displacement), acoustic masking, and (with very strong sounds) temporary or permanent hearing impairment. Injury by the shock wave resulting from impact of a large, fast-moving object with the water surface could be considered either an acoustic or non-acoustic effect. Possible non-acoustic effects include physical injury caused by falling debris, entanglement in debris, injury from Close-In Weapon System (CIWS) rounds, contact with hazardous constituents, ingestion of debris or hazardous constituents, and collisions with ships.

In the first part of this introductory section, we describe criteria that will be used in later sections to evaluate impacts. This is followed by brief reviews of acoustic properties of the main types of Navy activities occurring on the Sea Range (Section 4.7.1.2), hearing in marine mammals (4.7.1.3), noise effects on marine mammals (4.7.1.4), and relevant non-acoustic effects on marine mammals (4.7.1.5).

Appendix C, taken from the "Noise" section of the EIS/OEIS (Section 3.3), provides an introduction to some of the main acoustical issues.

4.7.1.1 Impact Criteria

This analysis deals primarily with the significance of impacts from the perspective of the National Environmental Policy Act (NEPA). Before proceeding with the analysis, it is necessary to define what constitutes a "significant" impact on marine mammals.

As defined in the Marine Mammal Protection Act (MMPA 1972, as amended 1994 – 16 U.S.C. § 1431 et seq.), the term "take" means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." Under the 1994 MMPA amendments, Congress defined and divided the term "harassment" to mean "any act of pursuit, torment, or annoyance which: (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A Harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B Harassment]."

For the purposes of the Point Mugu Sea Range EIS/OEIS, impacts are considered significant if they are predicted to have substantial long-term biological consequences to marine mammal populations. Minor and temporary behavioral responses with no likely consequences for the well being of individual marine mammals (e.g., minor startle or alert reactions) are not considered to be biologically significant. In some cases, there may be adverse impacts on individual marine mammals but these may not result in significant impacts to marine mammal populations. For example, if Navy activities on the Sea Range were to elicit stampedes into the water by pinnipeds hauled out on beaches, the possibility exists for injury or death of a small number of animals, especially pups. Although some individuals might be adversely affected, there would be no substantial or long-term consequences for the population provided that the numbers affected were small and did not involve threatened or endangered species. Further, there are no documented cases of injury or death to pinnipeds on the Sea Range as a result of stampedes triggered by military activities.

Impacts are considered significant if they are predicted to result in a reduction in the population size of any federally-listed threatened or endangered marine mammal species. In such cases, adverse impacts on individuals are considered potentially significant.

Possible Types of Acoustic Effects

Anthropogenic (man-made) sounds are known or suspected to have the following types of effects on marine mammals, depending on species, type of sound, proximity, duration of exposure, and other circumstances.

Disturbance: This can occur on the Point Mugu Sea Range, particularly for pinnipeds on beaches but to some extent for mammals in the water as well. Disturbance criteria for pinnipeds listening in air and underwater, along with toothed and baleen whales listening underwater, are discussed below. Disturbance responses can range from subtle changes in behavior detectable only through statistical analysis of quantitative behavioral data through brief alert or startle responses to short- or long-duration interruption of previous activities, with or without displacement. Disturbance responses often change upon repeated exposure to human activities.

Behavioral habituation is the gradual waning of behavioral responsiveness over time as the animal learns that a repeated or ongoing stimulus lacks adverse consequences for the animal. Habituation is common among cetaceans and especially pinnipeds exposed repeatedly to noisy activities that are not associated with any negative consequences to the animals (reviewed in Richardson et al. 1995a, pp. 317-321). Partial or perhaps complete habituation of disturbance responses has probably occurred in some situations on the Sea Range.

Disturbance often occurs without leading to significant impacts if the latter are defined as impacts involving long-term consequences to individuals or stocks. Occasional alert responses or short-term avoidance reactions to human activities may not have adverse effects on individual marine mammals or their populations. Alert and short-term avoidance reactions are common responses to some natural phenomena such as predators as well as to some human activities. Marine mammals tolerate some interruptions of normal activities and some episodes of avoidance in response to natural or man-made disturbance.

However, disturbance reactions may have adverse effects on individuals if triggered frequently, or if the disturbance could lead to injury, death, or permanent separation of dependent pups from their mothers. For example, low-altitude overflights of pinnipeds on haul-out sites sometimes cause animals to stampede into the water. At the least, this is a temporary disruption of normal behavior. More seriously, aircraft-induced stampedes sometimes injure or kill some pinniped pups (Johnson 1977; Richardson et al. 1995a). However, injuries or deaths during aircraft-induced stampedes have not been reported on the Point Mugu Sea Range. Disturbance could also be significant if it leads to disruption of biologically important activities like feeding, breeding, or nursing the young to the extent that there is a reduction in population size.

Acoustic Masking: Marine mammals are adapted to cope with momentary masking by natural environmental sounds, such as thunder, and with extended periods of elevated natural noise, such as occur during storms. Brief transient sounds, such as those from aircraft overflights, are the most common types of strong man-made sounds received by marine mammals on the Sea Range. Most individual marine mammals are exposed to these very infrequently. Infrequent and brief cases of masking by man-made sound are not expected to have any significant consequences for marine mammals.

Consideration would need to be given to masking if there were any sources of man-made sound to which mammals on the Sea Range might be exposed for extended periods. However, there are very few such sources. The most notable would be ship noise from a Fleet Exercise (FLEETEX). However, during a FLEETEX, high levels of continuous noise are limited to times when the ships are underway at high or at least moderate speed. In these cases, the ships remain in any one area for only short periods of time and the resultant masking is not a concern. The issue of ship noise is addressed in more detail in Section 4.7.2.1-B.

Hearing Impairment: The possibility of hearing impairment should be considered in the case of sources of strong sound, e.g., low-altitude overflights by supersonic targets, which cause sonic booms. The lowest Sound Exposure Levels (refer to Appendix C) at which Temporary Threshold Shift (TTS) is expected to become evident are discussed below for pinnipeds on land and in the water, and for toothed and baleen whales in the water. TTS is the mildest form of hearing impairment. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the noise ends. At least in terrestrial mammals, the received sound level from a single noise exposure must be far above the TTS threshold for there to be any risk of Permanent Threshold Shift (PTS), i.e., permanent hearing damage (Kryter 1985; Richardson et al. 1995a). Relationships between TTS and PTS thresholds

have not been studied in marine mammals but are assumed to be similar to those in humans and other terrestrial mammals.

Intact missiles or targets hitting the ocean's surface produce shock waves (McLennan 1997). These might, in rare circumstances, be strong enough to injure or kill nearby marine mammals. Shock waves strong enough to cause injury are not, strictly speaking, an acoustic phenomenon. However, those impacts would also produce a strong noise pulse that would propagate to longer distances (see Section 4.7.1.2-C). Hearing impairment in the form of TTS could extend out to distances beyond those where shock waves from a surface impact could injure non-auditory as well as auditory organs.

Zones of Acoustic Influence

To evaluate the potential effects of noise on marine mammals, it is conceptually useful to define zones or radii within which various effects are expected (Figure 4.7-1). The three zones that are relevant here are the zones of physical damage, responsiveness, and audibility. These zones are discussed in detail in chapter 10 of Richardson et al. (1995). Those authors also discuss the "zone of masking," which is generally not relevant here because of the transitory nature of most noises to which marine mammals on the Sea Range are exposed.

"Zone of Physical Damage": The smallest zone is the "zone of physical damage," including (in theory) death, injury, or permanent hearing loss. This zone is comparatively small because received levels of sound (or shock waves) must be very high to cause physical damage, and received levels generally diminish with increasing distance from the noise source. The zone of physical damage is an area where adverse impacts to individuals could occur if marine mammals were present and exposed to the high-level sounds.

"Zone of Responsiveness": This larger zone includes the area where animals respond behaviorally to the stimulus. As noted above, behavioral responses are often limited to subtle changes in behavior that are not immediately apparent to an observer (e.g., slight changes in breathing rates) or to brief alert or startle responses with no biological consequences to the animals. Other types of disturbance with potentially greater significance to marine mammals include interruptions of previous activities such as cessation of feeding or breeding behavior, and short- or especially long-term displacement. These latter types of effects might have negative consequences for the well being of some individual mammals and their populations.

"Zone of Audibility": The zone of audibility is the area within which the sound is detectable by the animal. This zone is usually (if not always) larger than the zone of responsiveness, and is much larger than the zone of physical damage. This zone is generally larger than the zone of responsiveness because the sound levels necessary to elicit overt disturbance reactions are usually higher than the minimum detectable sound level (Figure 4.7-1). Simple detection of a man-made sound does not always elicit an overt disturbance reaction, and does not result in an adverse effect unless it is strong enough to cause physical injury or a disturbance reaction with biological consequences.

Criteria of Acoustic Significance

Most activities conducted by the Navy on the Point Mugu Sea Range are transient from the perspective of a specific animal, with the potential source of disturbance at a given location lasting for no more than a few seconds, and in some cases for less than a second. This would remain so under the "Minimum Requirement" and "Preferred" alternatives. Also, as described in later sections, the frequencies and

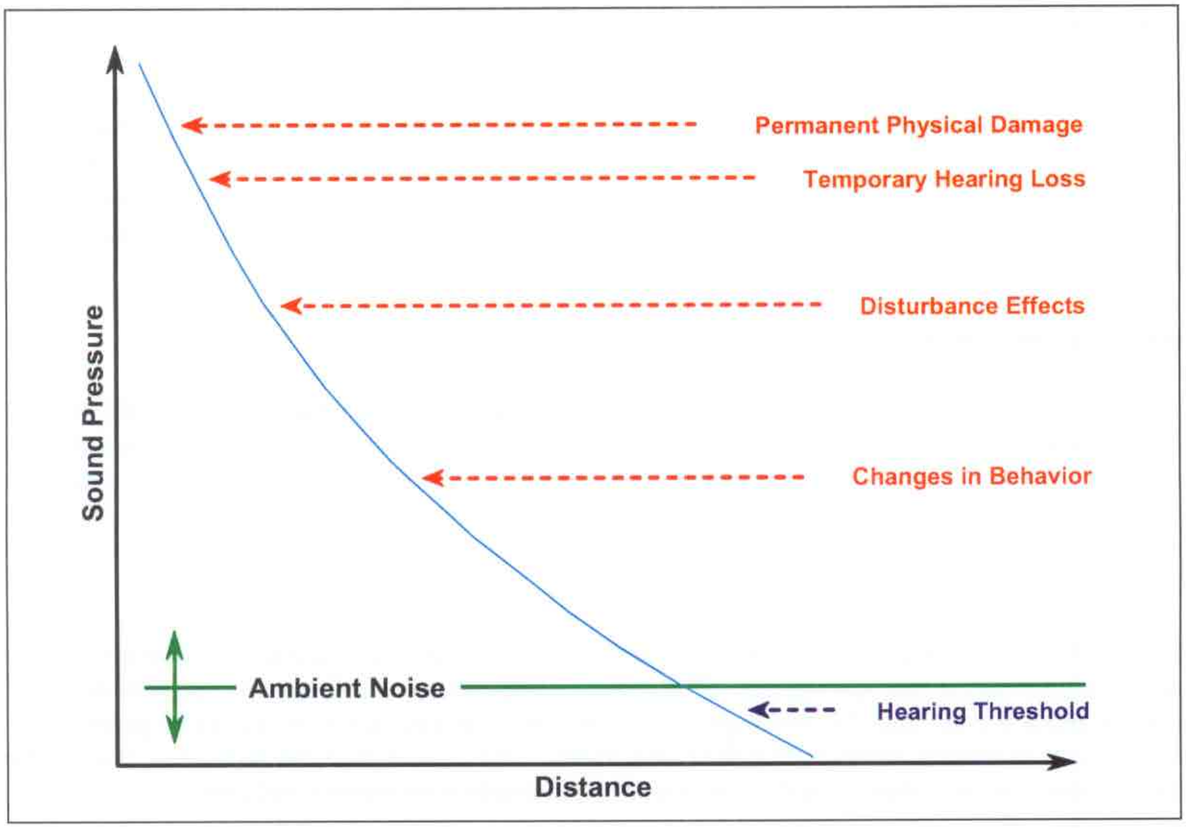


Figure 4.7-1
Potential zones of influence around a source of strong sound.
Note that received levels of most sounds are not sufficiently strong to cause permanent physical damage or temporary hearing loss at distances from the sound source where marine mammals are likely to occur.

distributions of most military activities on the Sea Range are such that any given animal is or would be exposed to strong noise transients only infrequently.

A few of the activities conducted by the Navy may result in prolonged exposure to sounds produced by Navy activities. For purposes of the Point Mugu Sea Range EIS/OEIS, prolonged exposure is taken to be "more than a few seconds." (Frequent exposure to transient sounds would fall into a similar category.)

Recently, there has been discussion about the use of the TTS threshold (minimum received level eliciting measurable TTS) as an objective criterion for the definition of an adverse effect on individual marine mammals, at least in the case of transient sounds (e.g., National Marine Fisheries Service [NMFS] 1995; Richardson 1997). TTS is the process whereby exposure to a strong sound results in a non-permanent elevation of the hearing sensitivity threshold (Kryter 1985). TTS can last from minutes or hours to days. The magnitude of TTS depends on the level and duration of noise exposure, among other considerations (Richardson et al. 1995a).

In this "Marine Mammal Technical Report" and in the associated EIS/OEIS, strong and/or prolonged disturbance is considered to have potentially adverse effects on individual animals, as is TTS. In rare

cases these adverse effects could be significant to marine mammal populations if they could result in reductions in their populations. However, momentary mild disturbance is considered to be less than significant. More specifically,

- Displacement of pinnipeds from beaches ("stampedes") could have adverse effects as it involves strong disturbance with the potential for injury of pups and separation of mothers from their pups. However, injury during stampedes triggered by military activities has not been documented on the Sea Range.

- For mammals at sea, exposure to prolonged activities is considered to have potentially adverse effects on individuals and potentially significant impacts on populations if the activities exclude the mammals from important areas, such as feeding, breeding, or nursing areas, for a period of days or longer. Temporary displacement for less than one or two days is considered to be less than significant provided there is no potential for injury, pup separation, or TTS, and provided that these incidents are infrequent for any one marine mammal.

- Exposure to brief transient sounds such as those from aircraft flyovers often causes alert or startle reactions without any extended interruption of prior activities. Brief alert or startle responses are not considered to have adverse effects unless they are accompanied by other indicators of more severe disturbance.

- Cases in which the received level of transient sound is high enough to cause TTS are considered to have adverse impacts on the individuals involved and may be potentially significant to their populations, depending on the severity of the TTS and the status of the animals involved:

    - Single or infrequent cases of mild TTS do not cause permanent hearing impairment, and are not likely to have adverse effects.

    - If threatened or endangered species are involved, even a single exposure to mild TTS might be considered significant.

    - Frequent exposure of the same individuals to transient sounds strong enough to cause TTS might be significant, but the analysis summarized later in this section indicates that this does not occur on the Sea Range.

Table 4.7-1 shows, for pinnipeds, toothed whales, and baleen whales, the received levels of transient and prolonged sounds at which potentially significant disturbance reactions may begin to occur. These criteria are based on the general principles outlined above. For pinnipeds, separate criteria are listed for in-air sounds and in-water sounds. Following convention, in-air and underwater levels are quoted in decibels with respect to 20 microPascals (20 μPa) and 1 μPa, respectively. For transient sounds, the levels are converted to a Sound Exposure Level (SEL) basis. The SEL approach standardizes to an assumed duration of 1 second. Additional rationale for each of the criteria listed in Table 4.7-1 is presented in Section 4.7.1.4.

Table 4.7-1. Assumed sound pressure criteria for disturbance and Temporary Threshold Shift (TTS) in pinnipeds and cetaceans. In-air criteria are in dB re 20 microPascals; underwater criteria are in dB re 1 microPascal.

Criteria	Pinnipeds	Toothed Whales	Baleen Whales
Disturbance from Prolonged Sounds in Air (dB re 20 μPa)[a]	100[b]	N/A	N/A
Disturbance from Prolonged Sounds in Water (dB re 1 μPa)[a]	140[c]	140 (120 for sperm whales)[c]	120[c]
TTS from Transient Sounds in Air (dB re 20 μPa SEL)	145 for harbor seals & California sea lions[d]; 165 for northern elephant seals[d]	N/A	N/A
TTS from Transient Sounds in Water (dB re 1 μPa SEL)	190[d]	190 [d]	180[d]

[a] For the purposes of the Point Mugu Sea Range EIS/OEIS, prolonged sounds are considered "more than a few seconds."
[b] Based on a review of published and reported behavioral responses to anthropogenic sound by pinnipeds hauled out in the Sea Range, as reviewed in this report.
[c] Based on a review of published and reported behavioral responses to anthropogenic sounds, many of which are described in Richardson et al. (1995a).
[d] Based on published threshold values for TTS in one toothed whale species and speculative inference from in-air human TTS values (Kryter 1985; Richardson et al. 1995a; Ridgway et al. 1997), plus criteria in NMFS (1995).

The estimated threshold criteria for behavioral disturbance are based on limited data. The provisional criteria should be tested with controlled experiments, or quantitative field observations coupled with accurate sound amplitude measurements, to establish more firmly the relationship between behavioral responses and the acoustic stimuli that elicit them. Likewise, the TTS criteria are based on very limited data, and need verification (see Section 4.7.1.4-A, later). With additional data of these types, the Navy and regulatory agencies would be better able to determine the circumstances in which individual marine mammals may be affected by anthropogenic noise in this area.

4.7.1.2 Types of Sound Sources and Their Estimation

Marine mammals rely heavily on the use of underwater sounds to communicate and to gain information about their surroundings. Thus, it can be assumed that they also hear many anthropogenic sounds. For some species of pinnipeds and toothed whales, this has been confirmed by direct measurements of hearing abilities (see Section 4.7.1.3, later). For baleen whales, there is strong indirect evidence that many man-made sounds are detected. There is concern about potential negative effects caused by the introduction of man-made noise into the marine environment. The reactions of marine animals to noise (underwater or in-air) can be variable and depend on the characteristics of the noise, the species involved, and the activity of the animal at the time of disturbance. Because underwater noise sometimes propagates for long distances, the radius of audibility can be large for strong noises. However, marine mammals usually do not react overtly to audible, but weak, anthropogenic sounds (Richardson et al. 1995a). Thus, the radius of responsiveness is usually much smaller than the radius of audibility (Figure 4.7-1).

The sea is a naturally noisy environment. The ability of marine mammals to detect and react to a man-made noise depends on the background or ambient noise level. Natural ambient noise both underwater and in the air along coastlines is related to sea state. Ambient noise tends to increase with increasing wind speed and wave height. In many areas, including southern California, shipping is a major contributor to ambient noise. Increases in ship traffic (and thus the shipping noise contribution to ambient noise) reduce the distances to which other man-made sounds can be detected by marine mammals. At closer distances, increases in ambient noise reduce the prominence (signal-to-ambient ratio) of the man-made sounds.

A - Sound Source Levels and Spectra

Most man-made noises that could affect marine mammals in the Point Mugu Sea Range arise from a few types of activities in and near the sea: FLEETEX and other ship movements, missile and aircraft overflights, missile and target impacts at sea and on land, and explosions and gunfire. Two or more of these sound sources may contribute to the total noise at any one place and time. A detailed discussion of the distribution and acoustic properties of a variety of military activities that occur, or are proposed to occur, in the Point Mugu Sea Range is included in Section 3.3 "Noise" of the EIS/OEIS.

The sound source is the initial element in the source-path-receiver model used to estimate the range to which a sound may be detected. Three interrelated parameters used to describe a source are its level, frequency, and temporal pattern. Source level refers to the amount of radiated sound at a particular frequency and distance, usually 1 meter (3.3 feet). For underwater sounds, source level is usually expressed in dB re 1 μPa at 1 meter (3.3 feet). For airborne sounds, the standard reference level is 20 μPa. Sources are categorized as "transient" if their duration is brief, as in the case of sound from missile launches, overflights, impacts, or explosions. Sounds are categorized as "prolonged" if (from the perspective of a particular animal) they persist for more than a few seconds, such as ship sounds from a FLEETEX. Spectra of transient sources are often determined from short segments of sound recorded when their source levels are highest. Noise from continuous sources may be averaged over a longer time period.

Source levels are rarely measured at the standard reference distance of 1 meter (3.3 feet). Instead, more distant measurements of received sound level are converted to an estimated source level by assuming or measuring the acoustic propagation loss from 1 meter (3.3 feet) to the actual measurement distance. We employed this procedure in evaluating the noise from some aircraft overflights and target launches (BQM-34 and Vandal) (for details, see Section 3.3 of the EIS/OEIS).

Aircraft, Target, and Missile Sound

Hubbard (1995) and M. Smith (1989) give comprehensive reviews of aircraft noise generation. Airborne sounds from aircraft are directly relevant to marine mammals that haul-out on land, and probably to marine mammals at the ocean's surface. Aircraft sound also propagates into the water where it will sometimes be detectable to marine mammals below the surface. However, the complex process of air-to-water transmission (see next section, Appendix C, and Section 3.3 of the EIS/OEIS) affects the characteristics of aircraft sound received by marine mammals below the surface. The level of underwater sound from any type of aircraft depends on receiver depth and the altitude, aspect, and strength of the noise source.

The received level of aircraft noise underwater can be estimated, if the source level is known, by applying the procedure of Young (1973, and Appendix C). Levels received underwater decrease with

increasing aircraft altitude, but estimated source levels are essentially independent of altitude, as expected. Large aircraft like the Navy's P-3 tend to be noisier than smaller ones. Helicopters are generally 10 dB noisier than fixed-wing aircraft of similar size. Helicopters tend to produce a larger number of tones and higher broadband noise levels.

Jet aircraft produce widely varying sound levels, depending on aircraft type, phase of flight, and other factors. Many high-performance military jets are extremely noisy, especially when using afterburners (e.g., F-4C twin-turbojet fighter, Table 3.3-1 of the EIS/OEIS). Given the lack of rotors and propellers, sounds from jets do not include prominent tones at low frequencies; broadband noise extends across a wide frequency range. Blade-rate tones account for the high-frequency squealing in jet sounds; the low-frequency roar is the jet mixing noise from the engine exhaust. The tones and jet mixing noise are directional (Smith 1989). The high-frequency tones are rapidly absorbed in the atmosphere. Hence, to a human listener a high-flying jet seems silent during approach and only the low-frequency rumble is heard from the after aspect of the aircraft.

Little information is available about sounds from subsonic target drones such as those used on the Point Mugu Sea Range. These are small unmanned aircraft powered by small turbojet engines. When launched from the surface, a solid rocket booster (usually called a "JATO bottle" for "jet assisted take-off") is used to boost the target up to the speed where its turbojet engine can sustain flight. The rocket booster produces strong noise for a brief period. To provide data needed for the present analysis, Burgess and Green (1998) measured the airborne sounds from the launch of a BQM-34S target at NAS Point Mugu. Likewise, little information is available about the launch noise of a supersonic target such as the Vandal targets launched at San Nicolas Island. Burgess and Green (1998) also measured the noise from Vandal launches.

An aircraft or target missile flying at supersonic speed produces a sharp, low-frequency pressure pulse at the surface (see discussion in Section 3.3 of the EIS/OEIS). The received waveform is nominally N-shaped, representing an initial rapid pressure increase corresponding to a bow shock wave, relaxation, and an abrupt return to ambient pressure corresponding to a tail shock wave. Sonic booms contain energy across a wide range of frequencies, but most is below 100 Hertz. Hubbard (1995) describes sonic boom generation, propagation, and measurements. During supersonic flights over water, little of the sonic boom energy reaching the surface propagates into the water. In addition to the review in Section 3.3 of the EIS/OEIS, Cook et al. (1972) and Sparrow (1995) provide more information about sonic booms as received underwater.

In summary, the sounds from aircraft and helicopters have most energy at frequencies below 500 Hertz. Helicopters tend to be noisier than similar-sized fixed-wing aircraft. Large aircraft tend to be noisier than smaller ones, and aircraft on takeoff or climb tend to be noisier than those during cruise or especially approach.

Vessel Sound

Ocean-going vessels all produce underwater sound and are major contributors to the overall background noise in the sea, given their large numbers, wide distribution, and mobility. Sound levels and frequency characteristics are roughly related to ship size and speed, but there is significant individual variation among vessels of similar classes.

The primary sources of sounds from all vessel classes are propeller cavitation, propeller singing, and propulsion or other machinery. Propeller cavitation is usually the dominant noise source (Ross 1976).

Unlike propeller cavitation and singing, which originate outside the hull of a vessel, noise from propulsion machinery originates inside and reaches the water via the vessel hull. Sources include rotating shafts, gear reduction transmissions, reciprocating parts, gear teeth, fluid flow turbulence, and mechanical friction. Propellers create more noise if damaged, operating asynchronously, or operating without nozzles. Other sources include auxiliaries (pumps, non-propulsion engines, generators, ventilators, compressors), flow noise from water dragging along the hull, and bubbles breaking in the wake. Ross (1976) provides a comprehensive review of vessel noise.

Much of the noise from vessels is composed of narrowband "tonal" sounds at specific frequencies. Sound levels and frequencies are related to vessel size, design, speed, and especially the number of blades on the propeller. Large vessels, such as aircraft carriers, create stronger and lower-frequency sounds because of their greater power, large drafts, and slower-turning engines and propellers. They also have large hull areas that efficiently couple the machinery sound to the water.

Most published data concern rather old vessels. Modern supertankers, bulk carriers, and container ships have been estimated to radiate noise 5 to 8 dB stronger than that from typical 1945-vintage ships (Ross 1976). Noise characteristics of modern military vessels are studied intensively but this information has not been published. Much effort has been given to quieting submarines and other naval vessels, but large ships operating at high speed are inevitably noisy.

Many studies of man-made noise and its biological effects have not considered frequencies below 10-20 Hertz. However, ships are known to emit strong infrasonic (<20 Hz) tones. In some cases, such as a supertanker or aircraft carrier, a high proportion of the emitted energy may be at infrasonic frequencies. The inconsistent availability of acoustic data from low frequencies is a significant data gap. It is not known how many marine mammals can detect infrasounds. Some of the baleen whales are the marine mammals most likely to do so. At least in deep water, where infrasounds sometimes propagate well, infrasonic components of man-made sound could be important to marine mammals. However, in shallow continental shelf waters, low-frequency sounds usually attenuate rapidly. Given this, plus the often-high ambient noise levels at low frequencies, strong infrasounds in nearshore areas may often be undetectable far from their sources even if marine mammals can hear at those frequencies.

Small boats equipped with outboard engines are employed during special warfare exercises in the littoral waters of the Sea Range, but there are few published measurements of their sounds (e.g., Moore et al. 1984). Large outboard engines can produce overall free-field source levels on the order of 175 dB re 1 μPa at 1 meter (3.3 feet). Noise levels associated with larger boats with inboard or outdrive engines depend on the size of the engine and its speed. The dominant frequency spectra from boats in this class contain strong tones at frequencies up to several hundred Hertz.

In summary, all vessels produce noise in the same ways. Propeller cavitation produces most of the broadband noise, with dominant tones arising from the propeller blade rate. Propellers create more noise if damaged, operating asynchronously, or operating without nozzles. Propulsion and auxiliary machinery can also radiate significant noise. Radiated noise is roughly related to ship size, speed, and mode of operation. Large ships (such as aircraft carriers) tend to be noisier than small ones, and ships underway with a full load (or towing or pushing a load) produce more noise than unladen vessels. Noise also increases with ship speed. Dominant frequencies tend to vary inversely with vessel size.

Ambient Sound

Ambient noise is environmental background noise. It is generally unwanted sound; that is, sound that clutters and masks other sounds of interest. Ambient noise includes only the sounds that would exist if the sensor were not there. Noise created by the measurement process, including any vessel or vehicle used to deploy the sound sensor, is usually excluded (Ross 1976). Ambient noise may have directional properties. Surf sounds coming from a shore, or distant shipping sounds from a shipping lane, are examples of directional ambient noise. Vertical directionality occurs at deep water sites. The published literature on ambient noise is very extensive. Many papers on underwater ambient noise appear in the *Journal of the Acoustical Society of America* and elsewhere. Ross (1976) and Urick (1983) include considerable discussion of ambient noise in the sea, and Urick (1986) is a monograph on this topic. Section 3.3 of the EIS/OEIS discusses the ambient noise on the Point Mugu Sea Range.

Airborne sounds from ships, boats, and helicopters can contribute significantly to the airborne ambient noise to which marine mammals are exposed when at the surface or hauled out (Section 2.3 in Brueggeman et al. 1990). However, little information has been published about overall levels of in-air ambient noise in coastal and marine areas located far from specific sources of man-made noise. Some limited information was given by BBN (1960) and Abrahamson (1974); this is summarized in Richardson et al. (1995a).

B - Modeling Received Sound Levels

The potential effects of noise on marine mammals are determined by radiated sound power levels, sound propagation characteristics, and the auditory and behavioral sensitivity of the mammals (for review, see Richardson et al. 1995a). Sound propagation has been the subject of intensive research. The open literature on sound propagation in air and water is voluminous, and there is much additional unpublished and classified information, especially on underwater propagation.

The audibility or apparent loudness of a noise source is determined by the radiated acoustic power (source level), propagation efficiency, ambient noise, and the hearing sensitivity of the subject species (see Appendix C). Site-specific sound propagation data (both in-air and underwater) are often lacking when a potentially noisy activity is planned. It is often not feasible to obtain site-specific sound transmission measurements to estimate how intrusive the new noise will be. However, predictions can often be made based on generalized propagation models developed for both airborne and underwater sound. These models provide procedures for estimating the received noise level as a function of distance, assuming that the source level and characteristics are known. These propagation models may be purely theoretical, based on physical principles; or semi-empirical, using both physical principles plus field measurements (as we have done for Vandal and BQM-34 target launches). Efforts to develop theoretical sound transmission models have been under way for several decades (see review in chapter 4 of Richardson et al. 1995a).

Model predictions can be useful for planning and for preparing environmental impact statements, but it is advisable to obtain relevant empirical data as well. This is important because of the highly variable and site-specific nature of underwater sound transmission, especially in shallow water, and of airborne sound transmission near the ground.

Airborne sound transmission is an important consideration in this analysis. Many of the sources of sound being considered here are in-air sources such as aircraft, targets, and missiles. Sound from these sources attenuates as it propagates through the air. Marine mammals hauled out on land or at the water's surface

may receive this airborne sound directly. Also, in-air attenuation must also be considered when assessing noise exposure of mammals that are underwater but receiving sound that originated in the air. Air-to-water propagation of sound is discussed in Section 3.3 of the EIS/OEIS.

Airborne and air-to-water propagation of sonic booms is a specialized subject, differing in several respects from propagation of other sounds. Cook et al. (1972) summarized air-to-water propagation of sonic booms created by supersonic aircraft. Although most energy is reflected upward when it reaches the sea surface, some penetrates into the water and creates considerable acoustic pressure near the surface. The strength of the low-frequency pressure pulse received underwater decreases rapidly with increasing depth. However, even at depths as deep as 330 feet (100 meters), the received level increases significantly with decreasing aircraft altitude or increasing aircraft speed (Sparrow 1995).

In summary, sound propagation research has made considerable progress in recent years. Field measurements of sound levels in relation to distance, frequency, and environmental parameters have been obtained in many areas and situations. Based on these data and on theoretical considerations, efficient computer models have been developed. Some models provide sufficient detail to account for many of the propagation processes occurring in the real world. However, most models are designed for specialized applications and are not easily generalized for use in predicting potential radii of influence for anthropogenic noise sources.

Fortunately, some simple and general relationships can be used to make estimates of transmission loss for many sources and locations, both underwater and in air. For example, the spherical spreading law with an added absorption loss term can be applied in the cases of (1) air-to-ground transmission from aircraft or other sources at elevation angles greater than 10° and (2) non-ducted, direct-path underwater transmission.

At frequencies below a few kilohertz, where most industrial and military noise energy is concentrated, the absorption coefficient is very low in water but higher in air (see Section 3.3 in the EIS/OEIS and chapter 4 in Richardson et al. 1995a). Thus the absorption term is generally negligible for underwater propagation of industrial noise over the limited ranges where spherical spreading applies. However, absorption can be significant for underwater propagation of high-frequency sounds and for airborne propagation of sounds. For broadband sources, calculations need to be made at several frequencies because the absorption coefficient, and usually also the source level, are frequency-dependent.

C - Modeling Underwater Shock Waves and Received Sound Levels

Intact targets and missiles hitting the ocean's surface produce shock waves and noise pulses with peak source levels on the order of 239 to 271 dB re 1 µPa at nominal 1-meter (3.3-foot) distance, and pulse durations of 0.5 to 2 milliseconds, depending on the size and speed of the object (McLennan 1997). Missiles and targets will hit the water with speeds of 300 to 3,000 feet per second (91 to 914 meters per second). For purposes of this assessment, impulses were estimated based on McLennan (1997). To estimate potential effects from impulses, it is assumed that the pulse produced by an object hitting the water has an instantaneous rise time and is similar to that of a high explosive detonation. Therefore, the literature on effects of high explosives has been used to estimate effects on marine mammals. This may result in some overestimation of effects, given that impulses from objects hitting the water (especially of slower objects) will differ in some respects from the impulses caused by detonation of high explosives. Specific physical characteristics of these impulses are not well defined, but the data on explosion effects provide some guidance. The following paragraphs summarize characteristics of the noise pulses from

explosions relevant to the later discussion of impulses created by intact missiles and targets hitting the water surface.

With the possible exception of underwater volcanic eruptions and major earthquakes, man-made underwater explosions are the strongest point sources of sound in the sea (Richardson et al. 1995a). Even a relatively small explosive charge detonated underwater can produce a high peak pressure, e.g., 267 dB re 1 μPa at 1 meter (3.3 feet). Pressure pulses from high explosives are one type of "noise" known to be able to cause physical injury or death to marine mammals (see Section 4.7.1.3).

For many decades, explosives have been used routinely underwater. Small underwater detonations of explosives are widely used for many purposes, military and civil. Depth charges, mines, torpedoes, and bombs have been discharged underwater in very large numbers during wartime and military training. During infrequent tests to confirm the resistance of military ships and submarines to underwater explosions, up to 10,000-pound (4,540-kilogram) charges of high explosive are detonated (e.g., U.S. Navy 1998).

Research on blast damage to animals has determined that, with high explosives, the initial positive acoustic impulse is closely correlated with organ damage. A Proceedings volume entitled "Effects of Explosives Use in the Marine Environment" presents much more information about explosions and their effects on marine life (G. D. Greene et al. 1985). Other relevant sources include O'Keeffe and Young (1984), Richardson et al. (1995a), and U.S. Navy (1998).

High explosive detonations have very short rise times of about 20 microseconds, shock pulse durations of about 0.2 to 0.5 milliseconds, and a velocity of detonation of 15,000 to 30,000 feet per second (4,570 to 9,140 meters per second; Urick 1975; Parrott 1991; Demarchi et al. 1998). After the initial shock pulse, pressure falls below ambient pressure and then rises to a second maximum known as the first bubble pulse. The time between the shock and the first bubble pulse is 0.17 to 0.5 seconds, depending on the size of the explosive (Demarchi et al. 1998). Effective broadband source levels for high explosive charges of 1 to 44 pounds (0.45 to 20 kilograms) are on the order of 267 to 280 dB re 1 μPa at nominal 1-meter (3.3-foot) distance (Richardson et al. 1995a).

The pulse produced by an object hitting the water at high speed is more similar to that from a high-explosive than to that from black powder, a seismic airgun, or another source of pulses with a comparatively slow rise time. Pressure pulses from black powder and airguns cause relatively little injury to fish (Hubbs and Rechnitzer 1952). Black powder deflagrations produce pulses with long rise times of about 1 millisecond and initial pulse durations of up to 6 milliseconds or more (Urick 1975; Parrott 1991). Single airguns produce pulses with rise times on the order of 1 millisecond, an initial positive pulse of 2 milliseconds duration, followed by a negative pulse of about 3 to 5 milliseconds duration (Parrott 1991).

There is a great deal of literature on the effects of shock waves produced by high explosives and airguns used for seismic exploration. Because the pulses produced by an object hitting the water are more similar to those produced by high explosives than other sources, we used the literature on effects of high explosives to approximate effects of pulses produced by objects hitting the water.

For high explosive detonations, mortality and damage correlate better with impulse, measured in units of pressure × time (Pascal•seconds), than with other blast parameters (Yelverton 1981). McLennan (1997) derived simple equations to estimate the peak source level (sl) of the pulse produced by an intact missile

hitting the water and its duration in milliseconds (τ) using the velocity of the missile and its surface area as input:

$$sl = 20 \times \log_{10} P_u + 120$$

$$\tau = m / \rho \times c \times a_m$$

where sl = source level in decibels re 1 µPa at 1 meter from the source, τ = pulse duration in milliseconds, $P_u = \rho c \times a_m / a_u \times v_i$, P_u = the pressure at the surface of a hemisphere of radius 1 meter and area $a_u = 2\pi\ m^2$, ρ = density of water in grams per cubic centimeter, c = velocity of sound in water in centimeters per second, a_m = the cross sectional area of the body in centimeters^2, m = its mass in grams, and v_i = its velocity in centimeters per second. This approach is conservative in that it overestimates the pulse produced by an object hitting the water (McLennan 1997). Peak source levels were reduced by 20 dB for an AltAir missile (McLennan 1997) and 15 dB for other missiles. The peak source level in dB re 1 µPa at 1 meter distance was then converted to impulse:

$$I_{source} = (10^{sl/20} \times \tau) / 1{,}000{,}000$$

where I = impulse in Pascal•seconds, sl = source level in decibels re 1 µPa at 1 meter, and τ = pulse duration in seconds.

An object hitting the water acts as a dipole source with most of the energy directed downward. Impulse at a given distance and depth from the source was estimated with the equation

$$I_{distance} = I_{source} \times \cos(\text{theta})/R$$

where I = impulse in Pascal•seconds, theta = the vertical angle from the impact site to the receiver (measured relative to vertical=0°), and R = the distance between source and receiver.

When in proximity to a hard (e.g., rock) bottom, shock waves may attenuate less rapidly than in open water. Hill (1978) and Wright (1982) suggest that calculated lethal ranges or safe distances should be doubled in these circumstances to ensure a conservative safety margin.

Intact missiles hitting the water produce a strong noise pulse as well as the aforementioned shock wave. Peak source levels were computed as above. McLennan's model predicts the peak pressure and time duration of an exponentially decaying impulse waveform similar to those produced by high explosives, but with a longer time constant. SEL is appropriate as a measure of transient sound with duration on the order of 1 second or less:

$$\text{SEL (dB re 1 µPa at 1 meter)} = sl + 10 \text{ Log } (\tau) - 3 \text{ dB}$$

where sl is the peak pressure (µPa at 1 meter) and τ is the pulse length (seconds). For example, using McLennan's calculations for an AQM-37E supersonic target striking the surface, sl=250 dB re 1 µPa at 1 meter, τ = 0.73 millisecond, and SEL=216 dB at 1 meter. We calculated sound pressure levels created by typical missiles when they suddenly hit the water based on the calculated source level (on an SEL basis) and distance from the contact point. The received sound levels at various distances were computed assuming that the source was a dipole. Spreading loss was approximated by

$$20 \log_{10} (\cos \text{theta}/R) \text{ dB}$$

where theta = the vertical angle from impact site to receiver as before, and R = the distance between source and receiver. The dipole component means that the sound level to which a marine mammal would be exposed would depend on its depth as well as distance from the source.

4.7.1.3 Hearing in Marine Mammals

Marine mammal hearing has been reviewed by several authors, notably Popper (1980a, b), Fobes and Smock (1981), Schusterman (1981a), Ridgway (1983), Watkins and Wartzok (1985), Johnson (1986), Nachtigall (1986), Moore and Schusterman (1987), Au (1993), and Richardson et al. (1995).

A - Hearing in Pinnipeds

Pinnipeds, in comparison with toothed whales, tend to have a lower "best frequency," poorer sensitivity at the best frequency, and a lower "high-frequency cutoff." (The "best frequency" is the frequency at which hearing sensitivity is highest; the "high-frequency cutoff" is the frequency above which hearing sensitivity deteriorates very rapidly.) However, underwater hearing sensitivity at low frequencies such as 100 Hz is better in phocid seals (hair seals or true seals) than in toothed whales or otariids (eared seals; Figure 4.7-2). In-air hearing of phocid seals is less sensitive than underwater hearing, and the upper frequency limit is lower. Otariid seals are similar to phocid seals with regard to underwater hearing sensitivity at moderate frequencies. In air, otariids apparently have slightly greater sensitivity and a higher high-frequency cutoff than do phocids. The relative sensitivities of aerial and underwater hearing are difficult to compare, but otariids and especially phocids are found to be more sensitive to sounds in water than in air. Elephant seals have lower aerial hearing sensitivity than harbor seals or California sea lions, but better underwater sensitivity than the other species, at least at low frequencies (Figures 4.7-3, 4.7-4; Kastak and Schusterman 1998).

Background ambient noise often interferes with the ability of a pinniped (or other marine mammal) to detect a sound signal even when that signal is above the absolute hearing threshold. With short signals, such as sonic booms and some of the other brief impulsive sounds to which marine mammals might be exposed on the Sea Range, auditory threshold increases (i.e., deteriorates) as pulse duration decreases below about 0.1-0.2 s.

B - Toothed Whale Hearing

Hearing abilities of some toothed whales have been studied in detail (reviewed in chapter 8 of Richardson et al. 1995a). Underwater hearing sensitivity of several species has been determined as a function of frequency. In most of these tests, hearing sensitivity was determined only for frequencies above 1 kHz. However, for two species, the bottlenose dolphin and beluga whale (*Delphinapterus leucas*), hearing sensitivity has been extensively studied at low as well as moderate and high frequencies (Figure 4.7-5). In addition, some low-frequency audiometric data have been obtained recently for the Pacific white-sided dolphin (Tremel et al. 1998; see Figure 4.7-2) and for the Risso's dolphin and the false killer whale (Au et al. 1997).

The small- to moderate-sized toothed whales whose hearing has been studied have relatively poor hearing sensitivity at frequencies below 1 kHz, but extremely good sensitivity at and above several kHz. There are no specific data on the absolute hearing thresholds of the large, deep-diving toothed whales, such as the sperm whale.

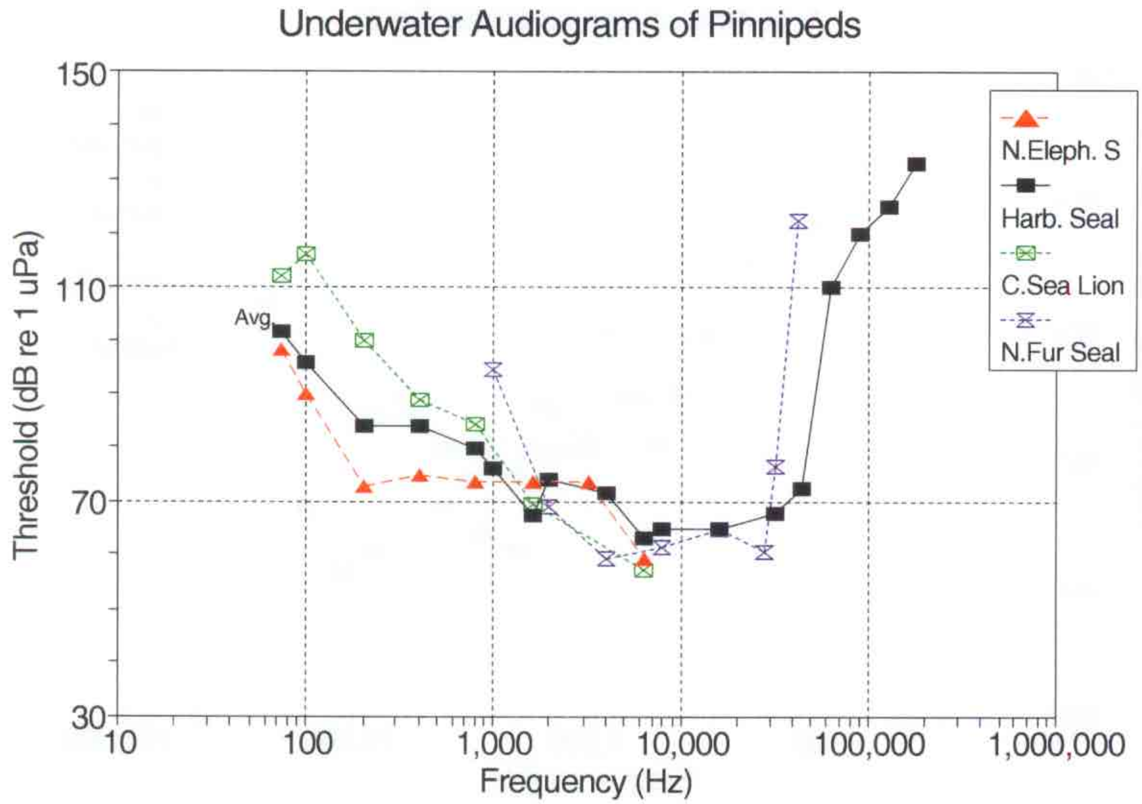


Figure 4.7-2
Underwater audiograms of selected pinniped species.
Adapted from Richardson et al. (1995a) based on

- **northern elephant seal and California sea lion (7-year-old) data of Kastak and Schusterman (1998),**
- **averaged harbor seal data of Møhl (1968), Kastak and Schusterman (1995, 1998), and Terhune and Turnbull (1995), and**
- **northern fur seal data of Moore and Schusterman (1987).**

The audiograms shown in Figure 4.7-5 refer to detection of pure tones of relatively long duration (0.2 second or more). For impulsive sounds less than 0.1-0.2 seconds in duration, detection thresholds of toothed whales are higher (Johnson 1968, 1991).

C - Baleen Whale Hearing

There is no direct information about the hearing abilities of baleen whales. Baleen whale calls are predominantly at low frequencies, mainly below 1 kHz (Richardson et al. 1995a), and their hearing is presumably good at corresponding frequencies. The anatomy of the baleen whale inner ear seems to be well-adapted for detection of low-frequency sounds (Ketten 1991, 1992, 1994). Thus, the auditory system of baleen whales is almost certainly more sensitive to low-frequency sounds than is the auditory

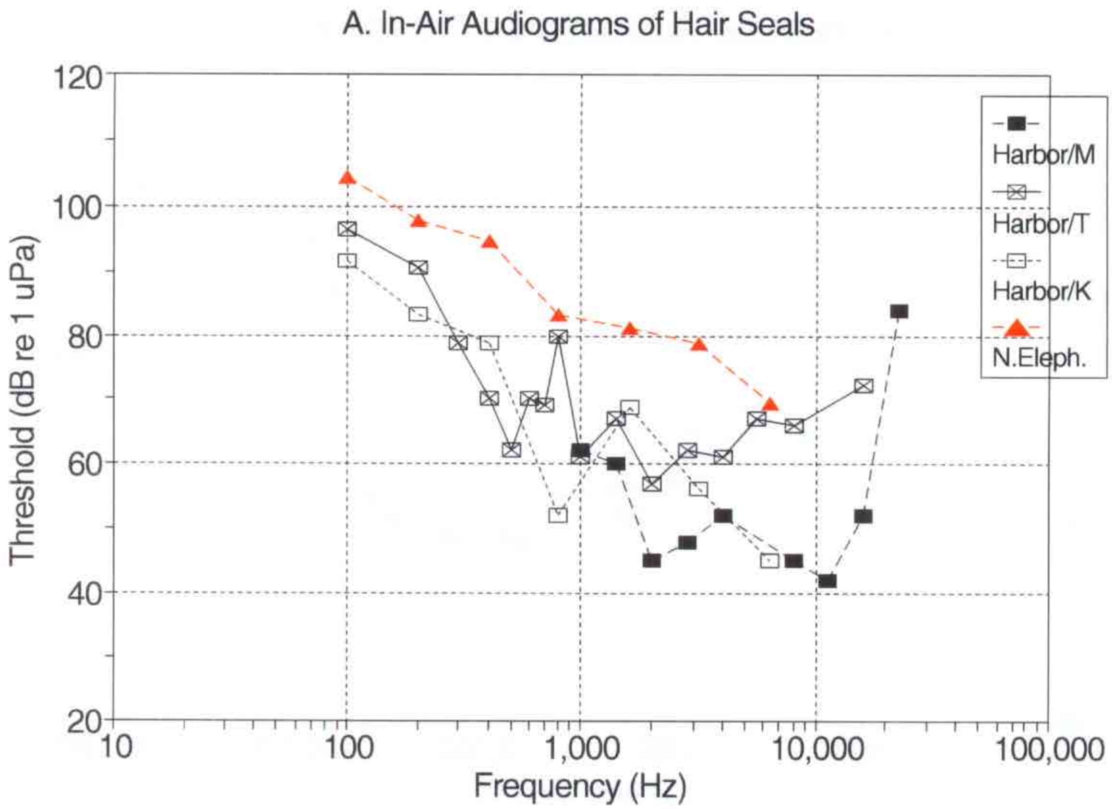


Figure 4.7-3
In-air audiograms of selected hair seal species.
Adapted from Richardson et al. (1995a) based on

- **harbor seal data of Møhl (1968), Kastak and Schusterman (1995, 1998), and Terhune and Turnbull (1995), and**
- **northern elephant seal data of Kastak and Schusterman (1998).**

system of the small- to moderate-sized toothed whales. However, auditory sensitivity in at least some species extends up to higher frequencies than the maximum frequency of the calls, and relative auditory sensitivity at different low-moderate frequencies is unknown. Baleen whales are known to detect the low-frequency sound pulses emitted by airguns and have been observed reacting to sounds at 3.5 kHz when received levels were 80-90 dB re 1 μPa (Todd et al. 1992). They also react to pingers at frequencies of 15 Hz to 28 kHz but not to higher frequencies (36 to 60 kHz) generated by pingers and sonars (Watkins 1986).

Sea Otter Hearing

There is no published information on sea otter hearing capabilities. As an indirect indication, most of the energy in the in-air calls of mothers and pups is at 3-5 kHz, but there are higher harmonics (Sandegren et al. 1973). Characteristics of underwater calls of sea otters have not been reported.

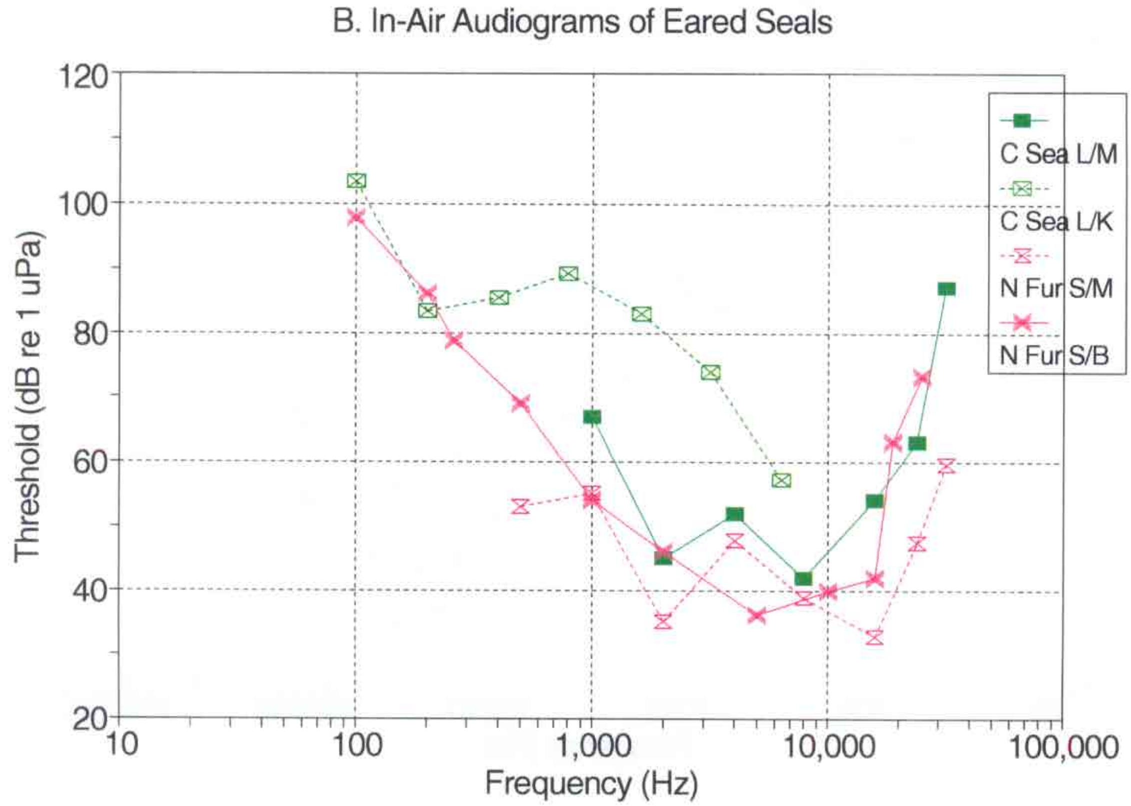


Figure 4.7-4
In-air audiograms of selected eared seal species.
Adapted from Richardson et al. (1995a) based on

- **California sea lion data of Moore and Schusterman (1987) and Kastak and Schusterman (1998), and**
- **northern fur seal data of Moore and Schusterman (1987) and Babushina et al. (1991).**

4.7.1.4 Review of the Effects of Noise on Marine Mammals

A - Pinnipeds on Land

Many researchers have described behavioral reactions of pinnipeds to human presence, boats, and aircraft. Although most of these data are anecdotal, they provide useful information about situations in which some species react strongly, react weakly or inconsistently, or do not react at all. No specific data on received sound levels are available for most of these incidents, but some reports mention the distances from sources where reactions were or were not found. Information about known reactions of marine mammals on the Sea Range is included within this and following subsections as appropriate.

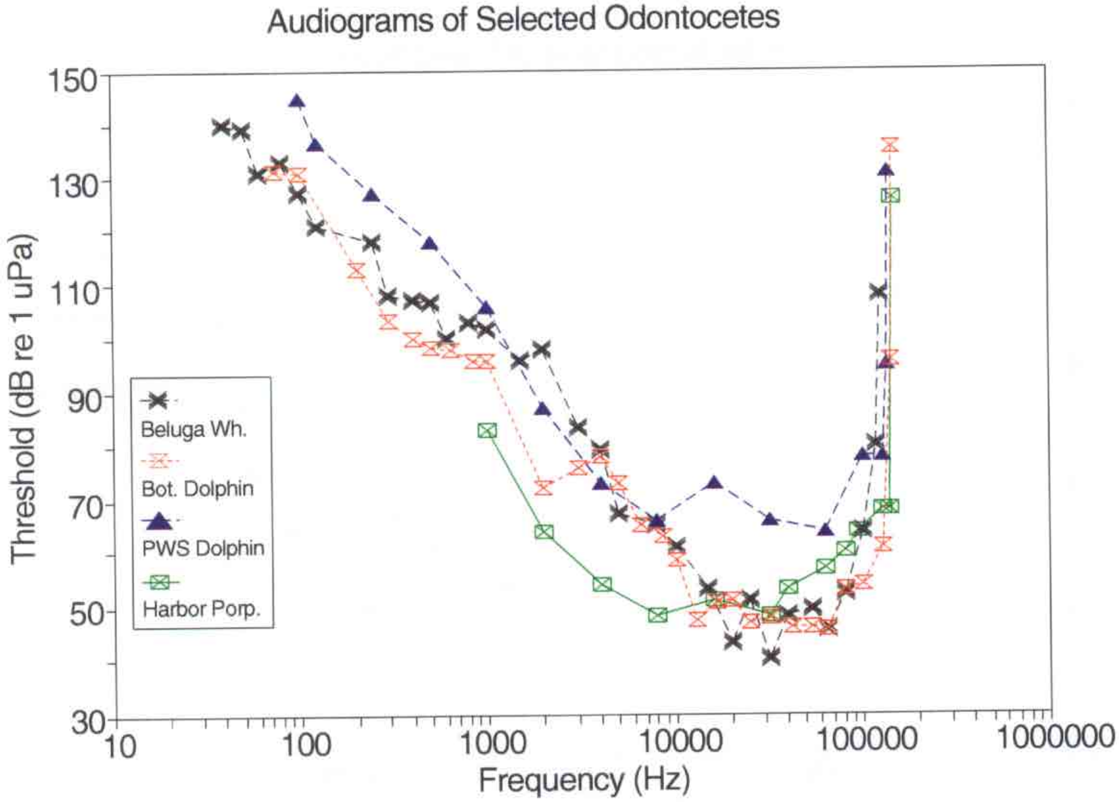


Figure 4.7-5

Underwater audiograms of selected toothed whale species, showing the minimum detectable sound level for tonal sounds at various frequencies.

Adapted from Richardson et al. (1995a) based on

- **bottlenose dolphin data of Johnson (1967),**
- **beluga data (averaged) of White et al. (1978), Aubrey et al. (1988), Johnson et al. (1989),**
- **Pacific white-sided dolphin data of Tremel et al. (1998), and**
- **harbor porpoise data of Andersen (1970).**

Almost all data on disturbance reactions of pinnipeds (and other marine mammals as well) have concerned short-term behavioral reactions. These studies often determined distances or received sound levels at which animals first reacted noticeably. In pinnipeds, recognized reactions usually involved cessation of resting or social interaction, and onset of alertness or avoidance. Observed avoidance reactions commonly involved movement from haul-out sites to water. Various other changes in behavior have also been attributed to disturbance. In most studies, little or no information has been obtained about the duration of altered behavior after disturbance.

Rarely is the significance of short-term behavioral responses to the long-term well-being of individuals and populations known. Most brief interruptions of normal behavior are likely to have little effect on overall energy balance and reproductive performance. However, physiological reactions may occur even if no overt behavioral response is evident (e.g., Chappell 1980; MacArthur et al. 1979,1982).

Uncertainties about physiological, long-term, and population consequences are common not only for pinnipeds, but for all types of marine mammals and all sources of disturbance.

In many cases, it is uncertain whether observed reactions of pinnipeds to noisy human activities were attributable to noise or to other stimuli. For pinnipeds within the Sea Range, most data concern reactions of hauled-out animals to airborne sounds. Comparing pinniped responses to anthropogenic sounds in the Sea Range vs. other localities may be of dubious legitimacy. There is evidence that pinnipeds in the Sea Range, and elsewhere, usually exhibit some degree of habituation to human activities to which they are familiar.

For this analysis, we reviewed the relatively few publications and available unpublished scientific reports that describe the behavioral responses of pinnipeds to the types of sound expected to be encountered at haul-out sites in the Point Mugu Sea Range, such as rocket launches, aircraft overflights, and sonic booms. We categorized the information according to whether the animals showed no apparent reaction, minor alert or startle reactions, or flushing, stampedes, or other movements. We also extracted, from the various publications and reports, whatever information was available about the received sound levels at which each of the reported behavioral responses (or lack of response) occurred. This information is summarized in Figure 4.7-6. Some of these studies are described in detail below. However, the following review also takes into account relevant studies conducted in places other than the Point Mugu Sea Range.

Reactions to Impulsive Noise

Pressure pulses from explosions and supersonic missiles hitting the water have higher peak levels than those from any other man-made source, and very rapid rise-times. At close distances, explosives also produce shock waves, which propagate in a different manner than acoustical energy. Shock waves from high explosives can cause severe physical injury and death (e.g., Yelverton 1981). Underwater and aerial explosions occur during some military operations. In addition, underwater explosions were the standard energy source for marine seismic exploration in past decades. In some countries, explosives are still used for certain marine and terrestrial seismic programs.

Northern fur seals breeding on land showed no visible reaction to large but muffled underground blasts from quarries 0.37 to 1.2 miles (0.6 to 2 kilometers) away (Gentry et al. 1990). Some non-breeding males within 1,000 feet (305 meters) looked up in response to the strongest blasts. South American fur seals and sea lions may also be quite unresponsive to blasting (R. Harcourt, *in* Gentry et al. 1990). Gray seals exposed to noise from Aquaflex linear explosives reportedly did not react strongly (J. Parsons, *in* G. D. Greene et al. 1985:283).

Pinnipeds seem quite tolerant of noise pulses from sonic booms, although reactions sometimes occur. The responses vary according to the season and age structure of the haul-out group (see sonic boom responses reviewed in Figure 4.7-6). Focused sonic booms from Titan IV rockets may reach 10 to 18 pounds per square foot (480 to 860 Newtons per square meter), although actual measurements suggested that the levels received downrange of South Vandenberg Air Force Base by pinnipeds were 8.4 to 9.5 pounds per square foot (402 to 455 Newtons per square meter). For longer-duration sounds, sound pressure levels for a Titan IV rocket launch as measured at Rocky Point (12.7 miles [20.4 kilometers] away from the launch pad) were only 96.2 dB re 20 μPa – equivalent to a freight train passing at 50 feet (15 meters). Prolonged or repeated sonic booms, very strong sonic booms, or sonic booms accompanying a visual stimulus such as a passing aircraft are most likely to stimulate seals to leave a haul-out area.

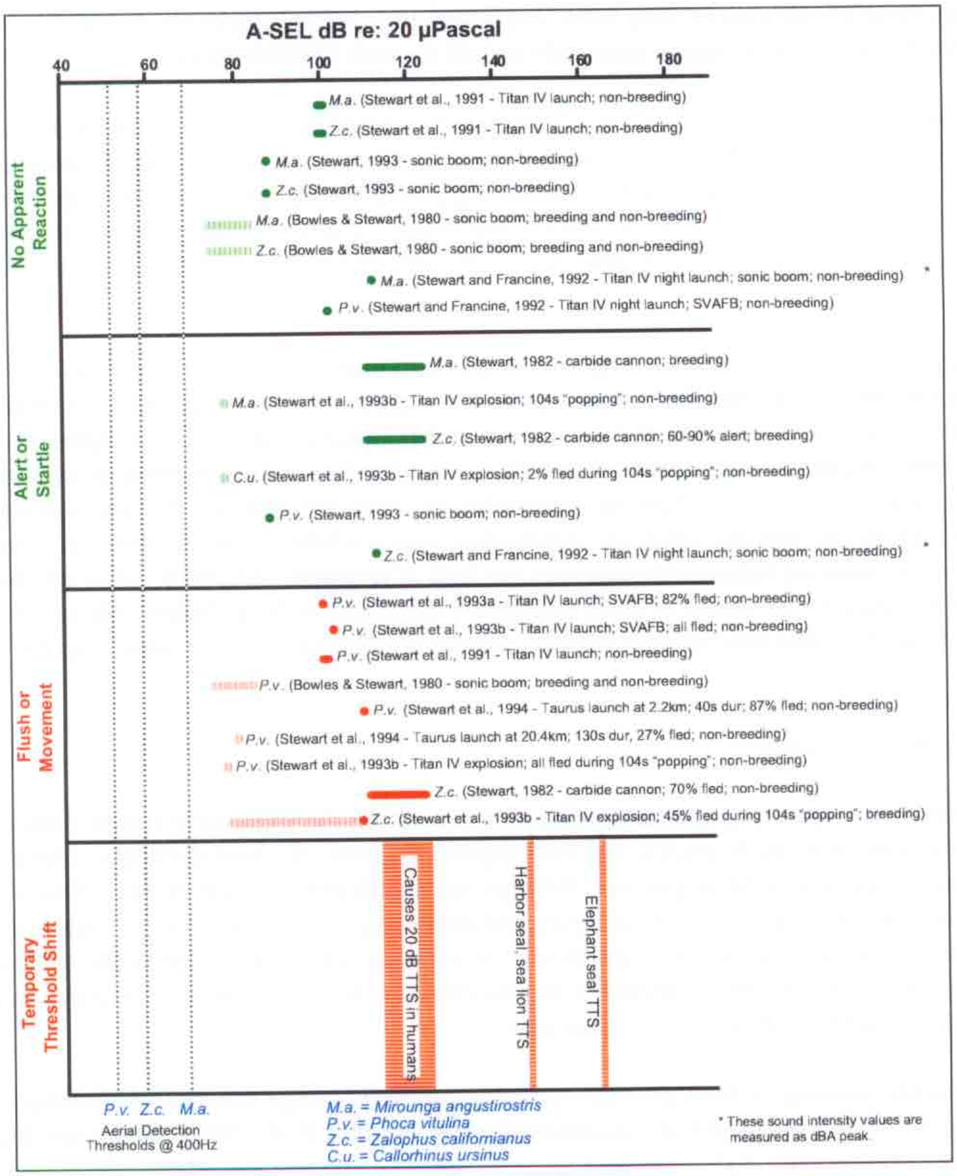


Figure 4.7-6

Behavioral responses by pinnipeds hauled out within the Point Mugu Sea Range to transient anthropogenic acoustic stimuli of varying source and intensity. The pinniped Temporary Threshold Shift (TTS) values were estimated based on comparisons with sound pressure levels known to cause TTS in humans, corrected for the higher (=poorer) aerial audibility thresholds of the three pinniped species.

Pinnipeds may be startled when first exposed to small explosions or larger muffled blasts. An acoustic stimulus with sudden onset (such as a sonic boom or gunshot) may be analogous to a looming visual stimulus (Hayes and Saif 1967), which can be especially effective in eliciting flight or other responses (Berrens et al. 1988). However, pinnipeds appear to become quite tolerant of noise pulses from both explosive and non-explosive sources, even though close exposure to blasts and other sources of strong impulses might cause hearing damage or other injuries (Richardson et al. 1995a).

Aircraft Overflights

Harbor seals hauled out in the Sea Range have reacted to aircraft overflights with alert posture and often with rapid movement, especially when the aircraft was visible (Bowles and Stewart 1980). Seals rushed into the water in response to some sonic booms and to a few of the overflights by light aircraft, jets above 800 feet (244 meters), and helicopters below 1,000 feet (305 meters). Sometimes the seals did not return to land until the next day, although they more commonly returned the same day (see Figure 4.7-6).

Likewise, Osborn (1985), also working in California, found that aircraft flying below 500 feet (150 meters) altitude over harbor seals caused alert reactions and, in 2 of 11 cases, rapid movement into the water. However, harbor seals can habituate to frequent overflights. Many aircraft using Vancouver International Airport fly low over a haul-out site. These seals show little or no reaction (M. Bigg, *in* S. R. Johnson et al. 1989:53). At Point Mugu, a blimp flying over at low altitude (100-200 feet [30-60 meters]) has been observed, on a few occasions, to cause harbor seals to move into the water (S. Schwartz, Point Mugu Environmental Division, personal communication, 1998). This reaction may be at least in part a response to the sight of the blimp, as the received noise level is apparently low.

Northern elephant seals and California sea lions at San Miguel Island, California, seemed less responsive than harbor seals (Bowles and Stewart 1980). Jets above 1,000 feet (305 meters) altitude produced no reaction; those below 1,000 feet (305 meters) usually caused limited movement but no major reaction. Light aircraft flying directly overhead at altitudes of 490 to 590 feet (150 to 180 meters) often elicited alert reactions and, in sea lions, movement (B. Stewart, personal communication, 1994, cited in Richardson et al. 1995a). Helicopters above 1,000 feet (305 meters) usually caused no observable response; those below 1,000 feet (305 meters) always caused the pinnipeds to raise their heads, often caused some movement, and occasionally caused "rushes" by some animals into the water. Helicopters that are turning or hovering sometimes caused mass movements even at ranges of approximately 1 mile (1.6 kilometers) and altitudes of approximately 980 feet (300 meters) if winds were calm or blowing from the helicopter toward the pinnipeds (B. Stewart, personal communication, 1994, cited in Richardson et al. 1995a).

Northern sea lions on haul-outs exhibit variable reactions to aircraft (Calkins 1979). Approaching aircraft usually frighten some or all animals into the water. Immatures and pregnant females are more likely to enter the water than are territorial males and females with small pups. Withrow et al. (1985) saw more than 1,000 animals stampede off a beach in response to a Bell 205 helicopter more than 1 mile (1.6 kilometers) away.

Northern fur seals on the Pribilof Islands sometimes stampede from rookeries and haul-outs in response to low-level overflights; stampedes are especially likely after July and among non-breeding fur seals (R. L. Gentry, *in* Herter and Koski 1988). Fur seals usually seem startled by sonic booms, and sometimes stampede into the water (A. Antonelis, *in* S. R. Johnson et al. 1989). However, stampedes do not always occur after overflights or sonic booms, and mortality apparently has not been noted (S. R. Johnson et al. 1989).

Recently, Greene et al. (1998a) observed the reactions of pinnipeds hauled out on San Nicolas Island to 12 overflights by an FA-18 jet fighter aircraft as it simulated sorties with the AGM-84E missile. The aircraft repeatedly passed over or near groups of California sea lions at altitudes ranging from 2,000 to 500 feet (610 to 150 meters) with varying power settings and speeds, and producing unweighted SEL levels of 110 dB re 20 μPa. In no case did the sea lions leave the beach, and rarely did these seals even exhibit alert reactions. The increase in airspeeds and decrease in altitudes were done gradually, so there may have been some habituation by the seals (Greene et al. 1998a).

Pinnipeds hauled out on land often react to the airborne sound and/or sight of aircraft by becoming alert and, less often, by rushing or stampeding into the water. If they react, reactions tend to be strongest if the aircraft is flying low, passes nearly overhead, causes abrupt changes in sound, or causes a sonic boom. Helicopters may be more disturbing than fixed-wing aircraft, but the lack of data on sound exposure levels makes this difficult to evaluate.

Pinniped startle or flight reactions to airborne noise often habituate, i.e., become less pronounced upon repeated exposure. Habituation occurs at different rates for different species, different populations, and different groups within a population as a function of age, sex, and time of day (Schusterman and Moore 1980). Pinnipeds hauling out at various places on or near the Point Mugu Sea Range often show little reaction to aircraft (potential impacts from aircraft overflights are addressed in Section 4.7.2.1). For example, harbor seals that haul out near the entrance to Mugu Lagoon are apparently habituated to the aircraft and helicopters that frequently fly overhead or nearby. However, on at least one occasion California sea lions (but not elephant seals) at San Nicolas Island were observed to stampede into the water upon exposure to three sonic booms in quick succession (G. Smith, Point Mugu Environmental Division, personal communication, 1998). Stampedes can increase pup mortality due to crushing or increased rates of pup abandonment (Johnson 1977; other studies reviewed in Richardson et al. 1995a: 243*ff*). This form of direct mortality has not been documented in the Sea Range, but on rare occasions a few pinnipeds might be injured or killed during stampedes.

Missile and Target Launches

Effects of missile and rocket-assisted target launches are special cases because of their high sound levels and sudden sound onsets (Cummings 1993). Effects of rocket launches on some pinnipeds have been studied. In most cases where pinnipeds in the Sea Range have been exposed to the sounds of large rocket launches (such as the Titan IV from Vandenberg Air Force Base), animals did not flush into the sea unless the sound level to which they were exposed was relatively high (potential impacts from missile and target launches are addressed in Section 4.7.2.1). Reactions of pinnipeds on San Nicolas Island to launches of Vandal targets have not been studied. On at least one occasion, launch of a medium-sized special missile from the west end of that island caused pinnipeds near the launch site to rush into the water. However, for the majority of launches from San Nicolas Island during which pinnipeds were observed, no stampedes were noted (S. Schwartz, Point Mugu Environmental Division, personal communication, 1998). Launches of BQM-34 target drones from NAS Point Mugu have not normally resulted in harbor seals leaving their haul-out area at the mouth of Mugu Lagoon about 2 miles (3.2 kilometers) to the side of the launch track.

In the Sea Range, sonic booms can be caused either by supersonic aircraft or missile overflights, or the launches of supersonic targets such as the Vandal. These booms have caused a startle reaction involving some movement into the water, and noise from a distant exploding rocket caused most sea lions (but not elephant seals) to stampede (Stewart et al. 1993). Bowles and Stewart (1980) suspected that disturbance-

induced stampedes or mother-pup separations may cause increased mortality. However, observations during actual sonic booms and tests with a carbide cannon simulating sonic booms provided no evidence of mortality.

Recent notices published by NMFS in the *Federal Register* suggest that the short-term impact of rocket launches is, at worst, a temporary reduction in utilization of haul-out areas; however no long-term stock or population effects are expected. Harbor seals are expected to exhibit startle responses to launch-related anthropogenic sound when hauled out near the launch sites.

Ship and Boat Traffic

There are many reports documenting that pinnipeds that are hauled out generally acclimatize and tolerate ship and boat traffic (Richardson et al. 1995a). This appears to be the case for harbor seals that haul out in Mugu Lagoon. (Potential impacts from ship and boat traffic are addressed in Section 4.7.2.1.)

Transient Activities – Summary and Criteria

As noted in Section 4.7.1.1, for pinnipeds on land, transient events will be considered to have adverse effects on individuals if there is potential for TTS or for the animals to stampede into the water. Momentary alert or startle reactions in response to a single transient sound are not considered to have adverse effects. The review summarized above indicated that a major behavioral disturbance (e.g., stampedes) is rare when pinnipeds on land are exposed to single transient sound stimuli. Therefore, in this analysis, the TTS criterion is the primary criterion of acoustic disturbance to pinnipeds on land.

Published TTS values obtained through experimental procedures are extremely rare for marine mammals. TTS studies in humans and terrestrial mammals provide helpful information, but it is unclear to what extent these data can be extrapolated to marine mammals. With the exception of an opportunistic observation by Kastak and Schusterman (1996) of TTS in a captive harbor seal, the only directed and published study of TTS in marine mammals was conducted by Ridgway et al. (1997). For bottlenose dolphins exposed to one-second pulses of underwater sound, TTS became evident at received levels of 194-201 dB re 1 μPa at 3 kilohertz, 193-196 dB at 20 kilohertz, and 192-194 dB at 75 kilohertz. These results are consistent with evidence from terrestrial mammals that TTS thresholds are not related strongly to the frequency of the sound (Richardson et al. 1995a).

For impulsive sounds, unpublished preliminary studies indicate that short-term (2.5 hours) TTS occurred in harbor seals exposed to simulated sonic booms of two to seven pounds per square foot and in California sea lions exposed to simulated sonic booms of 4 to 7 pounds per square foot (190 to 340 Newtons per square meter) (*Federal Register* 61(234), page 64340, comment 12). One pound per square foot (48 Newtons per square meter) is equivalent to 170 dB re 20 μPa, with a doubling of pressure yielding a 6 dB increase in sound level. This is below the level that would cause long-term auditory injury to pinnipeds. For impulsive sounds, sound pressure levels of 138 to 169 dBA are thought necessary to cause minutes-long TTS in humans, a species which hears better in air than pinnipeds (Chappell 1980).

There has been debate as to whether hearing thresholds and, by implication, TTS thresholds should be expressed in terms of sound pressure or sound intensity. This becomes important when comparing in-air versus underwater thresholds. The relationship between sound pressure and sound intensity is different in air vs. underwater as a result of the impedance differences between the two media. Kastak and Schusterman (1998) argue, in detail, the merits of formulating aerial and underwater threshold

comparisons using sound pressure. They suggest that pressure is the more appropriate measure for air/water comparisons in pinnipeds as they conclude that the pinniped ear appears to retain its pressure-transducing capabilities in air. Further, they point out that intensity thresholds are difficult to determine in captive test conditions. On the other hand, D. Helweg (in U.S. Navy 1998) asserts that aerial and underwater comparisons must be based on sound intensity (or power) as this scale accounts for media-dependent acoustic impedance. The debate is unresolved. In any case, there is no need to compare in-air and underwater sound criteria.

One means to estimate TTS thresholds for pinnipeds in air is to employ human TTS values estimated for brief sound exposure, in open-field conditions, to grazing-aspect sound impulses (such as gunfire). The human data must be adjusted to compensate for the poorer in-air auditory sensitivity of pinnipeds relative to humans (e.g., Terhune 1991; Kastak and Schusterman 1995, 1998; Richardson et al. 1995a). It can be estimated that harbor seals and California sea lions will probably begin to exhibit TTS in response to brief transient sounds at levels about 120 dB above their in-air hearing thresholds at their frequencies of best hearing (see Section 4.7.1.3). This is how human TTS thresholds are usually calculated (Kryter 1985; see also Chappell 1980). Elephant seals do not appear to hear as well in air as they do underwater (Kastak and Schusterman 1998; Section 4.7.1.3), so a higher assumed TTS threshold value is probably more appropriate for that species.

In the absence of specific TTS data for pinnipeds in air, **145 dB re 20 μPa A-SEL** is assumed to be the lowest level of transient sound that might cause TTS in harbor seals and California sea lions hauled out on land (Figure 4.7-6). For elephant seals, which have less-sensitive aerial hearing (Kastak and Schusterman 1998), a received level of **165 dB re 20 μPa A-SEL** is assumed to be appropriate. These assumed TTS thresholds for single transient sounds are 120 dB above the absolute hearing thresholds at the frequencies where these species hear best. This approach is based on methods used to derive human TTS thresholds for transient sounds (Kryter 1985). For additional details on pinniped hearing, see Section 4.7.1.3.

Single or occasional occurrences of mild TTS do not cause auditory damage in terrestrial mammals, and presumably do not do so in marine mammals. Very prolonged exposure to noise strong enough to elicit TTS, or shorter-term exposure to noise levels well above the TTS threshold, can cause PTS. Sound impulse duration, peak amplitude, and rise time are the main factors thought to determine the onset and extent of PTS. Based on existing data, Ketten (1995) has noted that the criteria for differentiating the sound pressure levels that result in PTS (or TTS) are location- and species-specific. PTS effects may also be influenced strongly by the health of the receiver's ear.

PTS is expected to be either absent or (at most) rare in marine mammals on the Sea Range:

- Most acoustic energy produced by military activities on the Sea Range will be transient, at least as experienced by any individual marine mammal, resulting in little probability of PTS.
- Except in the case of exposure to extremely high levels of transient sound, PTS occurs in other animals or humans only after long-term exposure (Kryter 1973, 1985).
- Most military activities occurring or proposed for the Sea Range do not expose marine mammals to sound levels high enough to cause strong disturbance or TTS; thus PTS (which requires exposure to higher levels) is not expected.

The one situation on the Sea Range in which PTS might occur would be that in which a supersonic missile hit the sea surface close to a marine mammal. The likelihood of such an event occurring close

enough to marine mammals to cause either TTS or injury (including PTS) is evaluated quantitatively later in this report.

Prolonged Activities – Summary and Criteria

For present purposes, prolonged activities are considered to be those from which a marine mammal will receive sound for more than a few seconds. Many of the "prolonged" activities to which pinnipeds on land might be exposed are in fact near the borderline between "brief transients" and "prolonged," continuing (from the perspective of a stationary marine mammal) for only a matter of several seconds. For example, the sound from the launch of a Vandal target at San Nicolas Island is in this category.

It is difficult to derive a clear criterion to identify situations in which prolonged or often-repeated sounds are expected to cause biologically-significant disturbance to pinnipeds on land. The available data are too limited, and the data that do exist are highly variable (Figure 4.7-6). In general, if the received level of the noise stimulus exceeds both the background (ambient) noise level and the auditory threshold of the receiving animals, and especially if the stimulus is novel to them, then there may be a behavioral response. The probability and type of behavioral response will also depend on the season, the group composition of the animals, and the type of activity in which they are engaged. As in the case of transient sounds, we consider minor and temporary responses such as startle or alert reactions not to be biologically significant. Stampedes into the water may have adverse effects on individuals because of the potential for injury or death of a small number of animals, especially pups.

In determining an acoustic sound pressure level criterion for pinniped disturbance in air, we took account of the fact that many pinnipeds that are exposed to Navy activities near haul-out sites will be familiar with those activities. The pinnipeds use traditional haul-out locations, and the Navy repeatedly uses the same launch sites, flight corridors, and impact sites. Therefore, in reviewing the available data on pinniped responses, we placed less emphasis on cases where disturbance appeared to result from unusual acoustic stimuli that were likely novel to the indigenous pinnipeds. This includes the extended series (104 seconds) of low-amplitude (78 dB A-SEL) "popping" sounds following the explosion of a Titan IV launch vehicle shortly after launch from South Vandenberg Air Force Base (Stewart et al. 1993). After an initial alert response by most seals, this disturbance caused 45 percent of the hauled-out California sea lions to flush into the water. This appeared to be an anomalous acoustic stimulus and an anomalous response. Sea lions in the Sea Range usually do not exhibit this degree of response to the sonic booms caused by rocket launches.

For prolonged activities, a sound pressure level criterion of **100 dB re 20 μPa** is considered appropriate as a disturbance criterion for pinnipeds hauled out within the Point Mugu Sea Range (Table 4.7-1). Stampedes of pinnipeds into the water rarely occur when received sound levels are less than 100 dB re 20 μPa. Stampedes occur during only a minority of exposures to 100 dB or more. Some animals (e.g., habituated animals) tolerate much higher sound levels without reacting strongly. In general, there is much variability, with some pinnipeds tolerating high levels of sound and others reacting to lower levels (Figure 4.7-6).

B - Pinnipeds in the Water

Reactions to Impulsive Noise

Although explosions are not involved in routine Sea Range operations, it is instructive to review the reactions of pinnipeds and other marine mammals to explosions in order to help assess their likely

reactions to other impulsive sounds. Underwater explosions are among the man-made underwater sound sources with highest sound pressure levels. Fishermen have employed them for many years as a means to control the behavior and distribution of marine mammals near their fishing or aquaculture operations.

Small explosives are often used in attempts to prevent pinnipeds from feeding around fishing gear (e.g., Mate and Harvey 1987). "Seal bombs" are firecracker-like explosives with up to a few grams of explosive, often fused to explode a few meters below the surface. They have source levels of approximately 200 dB re 1 μPa on a maximum fast SPL basis (Awbrey and Thomas 1987), and 220 dB re 1 μPa on a peak pressure basis (Myrick et al. 1990b). In contrast, shellcrackers and smaller pyrotechnics fired from pistols can explode above, at, or below the surface, with widely varying effective source levels. On the U.S. west coast, these devices initially startle seals and sea lions, and often induce them to move away from feeding areas temporarily (Mate and Harvey 1987). However, avoidance wanes after repeated exposure. Thereafter, some animals tolerate quite high levels of underwater sound pulses in order to prey on fish. Similarly, South African fur seals (*Arctocephalus pusillus*) that feed around fishing vessels generally dove or fled when firecrackers with 0.07-0.39 ounces (2-11 grams) of explosive detonated underwater, but returned within a few minutes (Anonymous 1972; Shaughnessy et al. 1981). Charges had to be thrown repeatedly to discourage feeding (Anonymous 1976). An arc-discharge device that created underwater noise pulses also had only limited value in scaring South African fur seals (Shaughnessy et al. 1981; Shaughnessy 1985). This device produced up to one pulse per 10 seconds with a low source level (132 dB re 1 μPa at 1 meter).

Results of monitoring studies during marine seismic exploration in the Beaufort Sea have shown that ringed seals (*Phoca hispida*) are quite tolerant of repeated strong pulses of low-frequency underwater sound (Harris et al. 1997, 1998). Some seals within about 490-820 feet (150-250 meters) from the source were displaced to somewhat greater distances, but other ringed seals remained within that radius as the seismic vessel approached. Within that radius, the received sound level below the surface often exceeded 190 dB re 1 μPa (root mean square [rms]). Even within that distance, there was little obvious effect on seal behavior. In general, ringed seals seemed quite tolerant of underwater noise pulses from seismic activities.

In summary, pinnipeds in water are generally very tolerant of impulsive sounds (Richardson et al. 1995a). It is not known whether pinnipeds in water would voluntarily remain near sources of impulsive sounds if levels were high enough to cause hearing impairment (temporary or permanent) or other injuries.

Aircraft Overflights

There are no published reports of the responses of pinnipeds to aircraft noise when they are below the water's surface and receive the sound there. The following examples are for pinnipeds that are at the surface, and therefore may hear and/or see the source of the sound in the air in addition to hearing it underwater.

There are few specific data on reactions of pinnipeds in water to either airborne or waterborne sounds from aircraft. During aerial surveys, seals in open water often dive when overflown by an aircraft at low altitude. However, some ringed seals surfaced within 66 to 98 feet (20 to 30 meters) of ice pans only a few minutes after a Bell 212 helicopter had landed and shut down no more than 130 feet (40 meters) from the ice edge (C. R. Greene, Greeneridge Sciences Inc., personal communication, 1998). Walruses in the water occasionally dive hastily when an aircraft passes overhead at 1,000 feet altitude (305 meters; Brueggeman et al. 1990). More definitive statements cannot be made because behavior before and after disturbances, and reactions to high-altitude flights, cannot be observed from the disturbing aircraft.

In any event, these behavioral reactions appear to be short-term. In the Sea Range, where pinnipeds on land appear to have accommodated to low-level overflights by aircraft and missiles (see above), reactions by pinnipeds in the water are expected to be infrequent, of brief duration, and do not have adverse effects on individual animals.

Ship and Boat Traffic

In general, evidence about reactions of pinnipeds to vessels is meager and is largely for species not found in the Sea Range. The limited data suggest that seals often show considerable tolerance of vessels, even when they are conducting noisy activities such as seismic operations (see Harris et al. 1997, 1998).

Transient Activities – Summary and Criteria

For pinnipeds in water, transient events are considered to have potentially adverse effects on individuals if TTS is expected. Transient events could cause significant effects depending on the severity of the TTS and the status of the animals involved (see Section 4.7.1.1). Momentary alert or startle reactions in response to a single transient sound are not considered to have adverse effects. TTS thresholds for pinnipeds in water have not been published. However, for seismic surveys, NMFS (1995) concluded that there would be no hearing damage or TTS to pinnipeds in the water if the received level of seismic pulses did not exceed 190 dB re 1 μPa. This criterion has been used in several recent seismic monitoring and mitigation programs (e.g., NMFS 1995, 1997).

Many of the strongest underwater sounds produced by Navy activities are impulsive or otherwise brief transients as received by an individual animal. Aircraft, targets, and missiles produce sound for an extended period, but the period during which a given animal may receive strong sounds from an aircraft, target, or missile flying over at low altitude is no more than a few seconds long. The duration of strong sound exposure is much less than 1 second for some of the strongest sounds like low-altitude sonic booms or missile impacts with the surface. Effects of brief transients on pinnipeds would be no greater than the effects of seismic pulses with similar received levels, and possibly less given the repeated nature of seismic pulses. Adverse effects on individuals and, in rare cases, potentially significant impacts on populations are assumed when underwater received levels of impulsive and transient sounds near pinnipeds exceed **190 dB re 1 μPa on an SEL basis**.

Prolonged Activities – Summary and Criteria

For pinnipeds in the water, prolonged activities will be considered to have a significant impact if there is a potential for the activities to exclude animals from important areas, such as feeding areas, for long periods of time. Temporary displacement (i.e., for a period of less than one to two days) is considered to be less than significant. The literature on pinniped reactions to prolonged exposure to underwater sounds indicates that pinnipeds generally tolerate exposure to high sound levels, especially when the animals are motivated to remain in the area to feed (Richardson et al. 1995a). There is no general consensus on an appropriate response criterion for this situation. However, based on the literature reviewed in Richardson et al. (1995a), it is apparent that pinnipeds exposed to prolonged or repeated underwater sounds are not likely to be displaced unless the overall received level is at least **140 dB re 1 μPa**.

C – Toothed Whales in the Water

Reactions to Impulsive Noise

Remarkably little systematic information is available about reactions of toothed whales to noise pulses.

There is some evidence that sperm whales are sensitive to noise pulses from seismic exploration. They may cease calling when exposed to weak noise pulses from extremely distant seismic exploration (greater than 186 miles or 300 kilometers away; Bowles et al. 1994). Sperm whales may move away from a seismic vessel at somewhat closer range (Mate et al. 1994), or behave unusually (S. M. Dawson, University of Otago, personal communication, 1998).

Most of the energy in seismic pulses is at low frequencies (<125 Hz), where the auditory systems of small and medium-sized toothed whales are not very sensitive. Even so, seismic pulses are strong enough to be detectable to small-to-moderate sized odontocetes many miles away (Richardson and Würsig 1997; Goold and Fish 1998). However, avoidance reactions by these animals may be limited to considerably smaller distances. Seismic operators sometimes see dolphins near operating airgun arrays (Duncan 1985). In the United Kingdom, common dolphins showed some avoidance of the area within approximately 0.6 miles (1 kilometer) of an operating seismic vessel (Goold 1996). Preliminary results from work in the Gulf of Mexico has shown little indication of effects from seismic exploration on small odontocetes (Rankin and Evans 1998).

During the 1950s, small explosive charges were dropped into an Alaskan river in attempts to scare belugas away from salmon. Success was limited (Fish and Vania 1971; Frost et al. 1984). Small explosive charges were "not always effective" in moving bottlenose dolphins away from sites in the Gulf of Mexico where larger demolition blasts were about to occur (Klima et al. 1988). Toothed whales may be attracted to fish killed by explosions, and thus attracted rather than repelled by "scare" charges. Hence, scare charges are now not used in the Gulf of Mexico platform removal program (G. R. Gitschlag, personal communication *in* Richardson et al. 1995a). Captive false killer whales showed no obvious reaction to single noise pulses from small (0.4-ounce [10-gram]) charges; the received level was approximately 185 dB re 1 μPa (Akamatsu et al. 1993). Jefferson and Curry (1994) review several additional studies that found limited or no effects on killer whales and other toothed whales.

Seal bombs were, until recently, used widely to influence the movements of the dolphins around which purse-seine nets are set during tuna fishing operations in the eastern Pacific Ocean (Cassano et al. 1990; Myrick et al. 1990a, b). The charges were thrown within meters of the dolphins in attempts to divert them onto a different heading. We are not aware of any detailed account of the behavioral reactions of dolphins at various distances from these charges.

In summary, there is little information on the effect of impulsive sound on toothed whales, and particularly on the specific pulse levels that may cause behavioral or other reactions. Some species may become silent (e.g., sperm whale) and/or move away from some sources of strong impulsive sounds, but the reactions vary depending on species and their activities. In the presence of abundant food or during sexual encounters, toothed whales sometimes are extremely tolerant of noise pulses. There is no evidence of long-term changes in behavior or distribution as a result of occasional exposure to pulsed acoustic stimuli.

Aircraft Overflights

When an aircraft flies low over a cetacean there is sometimes a discernible reaction. The reactions commonly consist of abbreviated surfacings, sudden dives or turns, rapidly swimming away from the aircraft track, and perhaps aerial behaviors (Richardson et al. 1995a,b; Patenaude et al. MS). Belugas often roll and apparently look upward at the aircraft.

Data on the reactions of species that are likely to be seen in the Sea Range are meager. Some sperm whales showed no reaction to a helicopter at very low altitude unless they were in its downwash (Clark 1956). Gambell (1968) mentions that sperm whales seemed unaware of a Cessna 310 observation aircraft, usually at 500 feet (150 meters) altitude. Mullin et al. (1991) reported that some sperm whales remained at the surface when a Twin Otter flew over at 500-750 feet (150-230 meters) altitude, but others dove immediately. Mullin et al. found that dwarf and pygmy sperm whales usually dove. Beaked whales seem especially sensitive to aircraft overflights, usually diving immediately and sometimes remaining submerged for long period thereafter (CeTAP 1982; Dohl et al. 1982; Mullin et al. 1991; Lynn et al. 1995). Dall's porpoises often dove, moved erratically, or rolled to look upward when a Bell 205 flew over at 700 to 1,200 feet (215 to 365 meters; Withrow et al. 1985). About 8 to 9 percent of Dall's porpoises changed direction suddenly or dove hastily when overflown by a Twin Otter aircraft at 200 feet (60 meters) altitude but only about two percent of delphinids showed such reactions (Green et al. 1992). Dolphins did not seem to react to a Bell 204 helicopter at 1,200 to 1,800 feet (365 to 550 meter) altitude (Au and Perryman 1982). Mullin et al. (1991) noted that bottlenose and most other dolphins generally did not react to a survey aircraft unless its shadow passed over them, whereupon they dove suddenly.

The activity of the animal at the time of the overflight tends to be related to the "severity" of the reaction, with feeding or socializing animals the least likely to respond. Responses range from no overt reaction to a dramatic disruption of activities. Possible reasons for this variation include whale behavior, aircraft altitude, engine setting changes, type of aircraft, weather conditions, and site location. Whales appear less disturbed by quiet aircraft flying at slow speeds and reduced engine power. Single overflights may elicit a sudden dive, which probably represents a startle reaction to the visual appearance or sudden noise of the aircraft. Reactions tend to be more common when aircraft altitude is low (e.g., 250 to 500 feet [75 to 150 meters]) than when it is higher (1,000 to 1,500 feet [305 to 460 meters]), but there is much variability. Continued harassment by an aircraft, such as prolonged circling overhead at low altitude, often results in dispersal of the individuals and departure from the area. However, single overflights generally do not appear to modify the distribution or behavior of animals for more than a few minutes, if at all. There is no evidence that aircraft overflights cause long-term displacement of whales.

In summary, most species of toothed whales do not appear to react to aircraft overflights, except when the aircraft fly at low altitude (below 500 feet [150 meters]). Beaked whales, pygmy and dwarf sperm whales, and Dall's porpoise appear to react more notably to low-level aircraft overflights than do dolphins or sperm whales. Whales that do react will dive hastily, turn, or swim away from the flight path. Feeding or socializing whales are less likely to react than whales engaged in other activities. Reactions to overflights, if any, appear to be brief and there is no evidence that infrequent aircraft overflights cause long-term changes in whale distribution.

Ship and Boat Traffic

Many toothed whales show no avoidance reaction to vessels, and sometimes approach them (e.g., to bow-ride). However, localized avoidance of vessels can occur. Beaked whales and harbor porpoises often show avoidance (e.g., Barlow 1988; Polacheck and Thorpe 1990; Palka 1993; Lynn et al. 1995).

Reactions can vary greatly even within a species. Avoidance is especially common in response to vessels of types used to chase or hunt the animals, although this is not an issue on the Sea Range. There is little evidence that toothed whales abandon areas because of vessel traffic.

Transient Activities – Summary and Criteria

For toothed whales (odontocetes) in water, transient events will be considered to have adverse effects on individuals if TTS is expected. They may be potentially significant to populations depending on the severity of the TTS and the status of the animals involved (see Section 4.7.1.1). Momentary alert or startle reactions in response to a single transient sound are not considered to have adverse effects. For seismic surveys, NMFS (1995) concluded that there would be no hearing damage or TTS to toothed whales in the water if the received level of seismic pulses did not exceed 190 dB re 1 μPa. Also, Ridgway et al. (1997) found that the TTS threshold of the bottlenose dolphin is about 190 dB re 1 μPa for a one-second sound pulse across a wide range of frequencies. Many of the sounds produced by Navy activities are impulsive or otherwise brief transients, as noted above for pinnipeds in the water. Effects on toothed whales are likely to be no greater than the effects of seismic pulses or the one-second pulses of Ridgway et al. (1997). Adverse effects on individuals and, in rare cases, potentially significant impacts on populations will be assumed when underwater received levels of impulsive and transient sounds near toothed whales exceed **190 dB re 1 μPa** on an SEL basis.

Prolonged Activities – Summary and Criteria

It is assumed that toothed whales exposed to prolonged sounds at received levels of **140 dB re 1 μPa** or above may show avoidance. The rationale for this 140 dB criterion is the same as for pinnipeds in the water exposed to prolonged sounds (see above). There is no general consensus on an appropriate response criterion for this situation. However, based on the literature reviewed in Richardson et al. (1995a), it is apparent that most small and medium-sized toothed whales exposed to prolonged or repeated underwater sounds are unlikely to be displaced unless the overall received level is at least 140 dB re 1 μPa.

The limited available data indicate that the sperm whale is sometimes more responsive than other toothed whales. A **120 dB re 1 μPa** criterion of disturbance by prolonged or repeated underwater sounds may be an appropriate conservative criterion for the sperm whale, as for baleen whales (see below).

Displacement of a small number of individuals for periods of a few days is considered to have adverse effects on individual whales. Longer-term displacement (i.e., for more than a few days), displacement of large numbers of individuals, or displacement of endangered species are considered to result in potentially significant impacts to populations.

D – Baleen Whales in the Water

Reactions to Impulsive Noise

As for toothed whales, almost nothing has been published about the reactions of baleen whales to noise from explosions. Gray whales exposed to noise from explosives "were seemingly unaffected and in fact were not even frightened from the area" (Fitch and Young 1948); no other information was given. Payne and McVay (1971), studying humpback whales, stated that "loud sounds in the ocean, for example dynamite blasts, do not seem to affect the whale's songs." Payne (1970) presented a recording of a humpback that continued to sing through the noise from two distant explosions. Lien et al. (1993) found

that humpbacks remained in an area where there were repeated large underwater detonations; whales that were observed directly during detonations apparently did not show obvious behavioral reactions. Some of these humpbacks may have been close enough to the blast site to suffer hearing damage or other physical injuries (Ketten et al. 1993; Ketten 1995).

More specific information about the reactions of some baleen whales to low-frequency noise pulses has been obtained by observing their responses to pulses from airguns and other non-explosive methods of marine seismic exploration. Humpback, gray, and bowhead (*Balaena mysticetus*) whales often seem quite tolerant of noise pulses from marine seismic exploration (e.g., Malme et al. 1984, 1985, 1988; Richardson et al. 1986; Ljungblad et al. 1988; Richardson and Malme 1993). The same may be true of fin and blue whales (Ljungblad et al. 1982; McDonald et al. 1993). These species usually continue their normal activities when exposed to pulses with peak received pressures as high as 150-160 dB re 1 μPa, and sometimes even higher. Such levels are 50-60 dB or more above typical 1/3-octave ambient noise levels. In those species, avoidance reactions are common when peak levels reach 160-170 dB, as typically occurs several kilometers from a vessel operating a full-scale airgun array. When bowheads are disturbed sufficiently to exhibit strong avoidance, they sometimes swim a few kilometers, and normal activities can be disrupted for an hour or more (Richardson et al. 1986; Ljungblad et al. 1988). The bowhead whale is closely related to the highly-endangered northern right whale, which might rarely occur in or near the Sea Range.

The received levels of seismic pulses quoted above are average or rms levels over the duration of the pulse, which–for seismic sounds–is typically about 0.1-0.3 seconds. On an SEL basis, the median avoidance threshold for baleen whale reactions to noise pulses is about 156 dB re 1 μPa. This value is based on observed reactions of gray, bowhead, and other baleen whales to series of airgun pulses. This figure is lower than the 160-170 dB values quoted above because SEL represents average pressure over 1 second.

Although baleen whales often tolerate high levels of noise pulses from seismic operations, subtle effects sometimes occur at lower received levels, at least in bowheads and possibly in gray whales (Malme et al. 1984; Richardson et al. 1986; Miller et al. 1999). Recent seismic monitoring work has confirmed that migrating bowhead whales avoided passing within approximately 11 NM (20 kilometers) of a seismic operation, apparently by adjusting their headings slightly as they approached (Miller et al. 1999). Received levels of the pulses at 11 NM (20 kilometers) range were about 120-130 dB re 1 μPa on an rms basis; peak pressures were about 10 dB higher (Greene et al. 1998b). Received levels would have been slightly lower at the somewhat greater distances where the deflection began. Thus, some baleen whales show subtle reactions to extended series of low-frequency noise pulses at received levels well below those recognized as causing overt avoidance.

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises provide no information about long-term effects. It is not known whether impulsive noises affect reproduction rate or distribution and habitat use in subsequent days or years. Gray whales continue to migrate annually along the west coast of North America despite intermittent seismic exploration in that area for decades (Appendix A *in* Malme et al. 1984). Bowhead whales continue to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years. Bowheads are often seen in summering areas where seismic exploration occurred in preceding summers (Richardson et al. 1987). They also have been observed over periods of days or weeks in areas repeatedly ensonified by seismic pulses. However, it is not known whether the same individual bowheads were involved in these repeated observations (within and between years) in strongly ensonified areas. It is also not known whether whales that tolerate exposure to seismic pulses are stressed.

In summary, baleen whales (mainly humpback, gray, and bowhead whales) often have been observed behaving normally, insofar as could be determined, in the presence of strong noise pulses from distant seismic vessels or, in a few cases, distant explosions. However, most gray and bowhead whales show some avoidance of areas where there are repeated noise pulses with received pulse pressures exceeding 160-170 dB re 1 μPa (SEL near 156 dB re 1 μPa). Subtle behavioral and avoidance reactions sometimes occur at lower received levels.

Aircraft Overflights

Reactions to aircraft overflights and the factors influencing those reactions are similar for baleen whales as for toothed whales (described above).

Right whales often seem to tolerate a light single-engine aircraft circling overhead. Watkins and Schevill (1976, 1979) observed feeding behavior of northern right whales by circling 165-1,000 feet (50-305 meters) overhead in a light aircraft. Payne et al. (1983) state that southern right whales (*Eubalaena australis*) off Argentina rarely reacted strongly to a light aircraft circling at 200 to 500 feet (60 to 150 meters). A few, probably less than two percent, swam rapidly or dove as the aircraft passed overhead. Off Australia, southern right whales showed no overt response to single overflights by a light aircraft but dives by adults were longer and surfacings were shorter (a subtle indication of disturbance) when the aircraft circled at 500 feet (150 meters) altitude (Ling and Needham 1990). Socializing or large groups of whales appeared to be more likely to react to aircraft overflights than single animals or small groups (Payne et al 1983; Fairfield 1990).

The proportion of bowhead whales that react to aircraft overflights depends on the altitude of the aircraft. When overflights were at 1,500-2,000 feet (460-610 meters) altitude, bowheads rarely reacted. They reacted to a higher proportion (though still a minority) of the overflights at 450 feet (140 meters) altitude (Richardson et al 1985; Patenaude et al. MS). Also, responsiveness to an aircraft at a given altitude was variable. Bowheads in shallow water and resting bowheads were most responsive, and those actively feeding, socializing, or mating were least responsive. Repeated low-altitude overflights (during aerial photogrammetry) sometimes elicited abrupt turns and hasty dives; however, many of these individual whales were photographed in the same area on subsequent days, suggesting that the low-level overflights did not displace many (if any) bowheads from feeding areas (Koski et al. 1988).

SRA (1988) stated that migrating gray whales never reacted overtly to a Bell 212 helicopter at higher than 1,400 feet (425 meters) altitude, but occasionally reacted when it was at 1,000 to 1,200 feet (305 to 365 meters) and usually when it was below 820 feet (250 meters). On the other hand, migrating gray whales reacted to underwater playbacks (3 simulated passes per minute) of Bell 212 sound. Whales changed course and some slowed down. Ten, fifty, and ninety percent of the animals showed minor avoidance reactions at received levels of 115, 120, and 127 dB re 1 μPa. It is unknown whether whales would have reacted to a single flyover, but the whales reacted to the sound *per se* since a real helicopter was not present.

Gray whales in the calving lagoons in Baja California churned the water with flukes and fins in response to being herded by helicopters at very low altitude. Mothers occasionally "shielded" calves with their bodies (Walker 1949), as observed in summer (Ljungblad et al. 1983). Harassment by low-flying (lower than 250 feet [75 meters]) aircraft causes the animals to dive and occasionally leads to separation of mother and young (Withrow 1983).

Humpback whale reactions to aircraft have been mentioned by several authors and appear to be variable. Some humpbacks were disturbed by overflights at 1,000 feet (305 meters) but others showed no reaction to flights at 500 feet (150 meters; Shallenberger 1978). Responses to a small aircraft depended on group size and composition; whales in larger groups showed little or no response and some all-adult groups exhibited avoidance (Herman et al. 1980). Authors reporting no response included Friedl and Thompson (1981), who detected no reaction at 500 to 1,000 feet altitude (150 to 305 meters), and Kaufman and Wood (1981). Helicopter disturbance to humpbacks is a concern off Hawaii (Tinney 1988; Atkins and Swartz 1989). Helicopters and fixed-wing aircraft are prohibited from approaching within a slant range of 1,000 feet (305 meters) from humpback whales near Hawaii (NMFS 1987).

Less information is available about reactions of other species of baleen whales. Minke whales usually responded to an H-52 turbine helicopter at 750 feet (230 meters) by changing course, rolling on their side, or slowly diving (Leatherwood et al. 1982). IWC (1990) mentions that minke whales off Norway were disturbed by a helicopter. A few minke and fin whales off Alaska reacted to a turbine survey aircraft by diving briefly (Ljungblad et al. 1982). Watkins (1981) was able to observe the behavior of fin whales from a light aircraft circling at 160-1,000 feet altitude (50 to 305 meters), but he implied that engine noise or the aircraft shadow sometimes caused reactions.

In summary, baleen whale reactions to aircraft flights are highly variable and depend on the species and activity of the animals. Most baleen whales are tolerant of single aircraft overflights, except (on some occasions) at altitudes lower than 500 feet (150 meters). Even then, the reactions are short-term (e.g., a single hasty dive). There is no evidence that a single overflight causes more than short-term changes in distribution and behavior.

Ship and Boat Traffic

When baleen whales receive low-level sounds from distant or stationary vessels, the sound often seems to be ignored. Some whales, especially minke whales, sometimes approach the sources of these sounds. When vessels approach whales slowly and non-aggressively, whales often exhibit unhurried avoidance maneuvers. In response to strong or rapidly-changing vessel noise, baleen whales often interrupt their activities and swim rapidly away. Avoidance is especially strong when a vessel heads directly toward the whale. Some whales travel as much as a few miles from their original location in response to a straight-line pass by a vessel through that site. Avoidance responses are not always effective in preventing collisions, injury, and mortality of baleen whales, especially the slower-swimming species such as gray and right whales (reviewed in Richardson et al. 1995a).

Transient Activities – Summary and Criteria

For transient events, NMFS (1995) concluded that there would be no effect on hearing sensitivity in baleen whales if received levels of sound pulses do not exceed 180 dB re 1 µPa. This is an assumed value as there are no specific data on TTS or auditory thresholds in baleen whales. Momentary alert or startle reactions in response to a single transient sound are not considered to have an adverse effect. NMFS often assumes a disturbance threshold of 160 dB 1 µPa for baleen whales exposed to repeated transient pulses, e.g., from seismic exploration (e.g., NMFS 1997). However, most exposures of baleen whales on the Point Mugu Sea Range to transient sounds involve single transients, for which this report and the associated EIS/OEIS consider the assumed 180 dB TTS criterion to be more appropriate. Adverse effects will be assumed when underwater received levels of impulsive and transient sounds near baleen whales exceed **180 dB re 1 µPa on an SEL basis**. These effects could be significant if they involve repeated exposure of some individuals, large numbers of individuals, or endangered species.

Prolonged Activities – Summary and Criteria

Baleen whales exposed to steady sounds of 120 dB re 1 µPa sometimes (but not always) exhibit displacement (Malme et al. 1984; Richardson et al. 1995a). We conservatively assume that adverse effects may sometimes occur when underwater received levels of continuous or prolonged sounds near baleen whales exceed **120 dB re 1 µPa**. It should be noted that the apparent avoidance threshold for gray whales exposed to repeated pulses of seismic sound was much higher, near 156 dB re 1 µPa SEL. Thus, the 120 dB criterion may be very conservative if applied to repeated transient sounds or to sounds that barely qualify as "prolonged" under our definition (e.g., several seconds in duration).

D - Effects of Noise on Sea Otters

The only information on the reactions of sea otters to impulsive sounds (airgun pulses) suggests that they are very tolerant of such sounds (Riedman 1983, 1984).

We are not aware of any published data on the reactions of sea otters to aircraft overflights.

The few data on reactions of sea otters to ships or boats indicate that sea otters generally tolerate close approaches (a few hundred yards). Sea otters sometimes move away from the vessel's trackline when a vessel approaches closer than a few hundred yards (e.g., Udevitz et al. 1995), but this displacement is probably localized and temporary. Sea otters on land may move into the water when a vessel travels along the coast 330 feet (100 meters) from shore (Garrott et al. 1993).

4.7.1.5 Non-Acoustic Effects

A - Debris

Injury from Falling Debris

Large pieces of falling debris from missiles or targets may strike and injure or kill marine mammals. As a general guideline, pieces of debris with an impact kinetic energy of 11 foot-pounds (15 joules) or higher are hazardous to humans (Cole and Wolfe 1996; Appendix G *in* U.S. Air Force 1997b). The number of marine mammals likely to be hit directly by falling debris can be estimated based on the densities of marine mammals derived in the previous chapter of this report plus estimates of the amount, sizes, and distribution of the falling debris. These calculations consider only the animals at or near the surface at any given time. Estimates of the numbers of marine mammals likely to be hit directly by falling debris in the Point Mugu Sea Range are presented in Section 4.7.2.1-C for the "No Action Alternative" (current operations). Sections 4.7.3.1 and 4.7.4.1 give corresponding estimates for the "Minimum Requirement Alternative" and the "Preferred Alternative." As shown there, the probability that even a single marine mammal will be hit in any given year is very low under any of the alternatives.

Injury from Intact Missiles and Targets

For the purposes of this analysis, it is assumed that impulses produced by intact missiles and targets hitting the water are similar to those produced by explosives (see Section 4.7.1.2-C). Shock waves that result from explosions, because of their high peak pressures and rapid changes in pressure (fast rise time), can cause severe damage to animals. The most severe damage takes place at boundaries between tissues of different density. Different velocities are imparted to tissues of different densities, and this can

physically disrupt the tissues. Gas-containing organs, particularly the lungs and gastrointestinal tract, are especially susceptible (Yelverton et al. 1973; Hill 1978). Lung injuries can include laceration and rupture of the alveoli and blood vessels. This can lead to hemorrhage, creation of air embolisms, and breathing difficulties. Intestinal walls can bruise or rupture, with subsequent hemorrhage and escape of gut contents into the body cavity. For detonations of high explosive, mortality and damage correlate better with impulse, measured in units of pressure × time (Pascal•seconds), than with other blast parameters (Yelverton 1981).

Yelverton (1981) produced equations for computing safe distances of mammals from an explosive source taking account of the animal's body mass. Large mammals are less susceptible than smaller ones. The impulse levels that kill or damage mammals have been determined empirically to be as follows (from Yelverton 1981):

50 Percent Mortality	$\ln(I) = 4.938 + 0.386 \ln(M)$
1 Percent Mortality	$\ln(I) = 4.507 + 0.386 \ln(M)$
No Injuries	$\ln(I) = 3.888 + 0.386 \ln(M)$

where I = impulse in Pascal•seconds and M = body mass in kilograms. These equations are based on data from submerged terrestrial mammals exposed to high explosive detonations. They may overstate the severity of injuries to marine mammals adapted for life in the water, especially when exposed to impacts associated with shock waves from intact missiles hitting the water rather than explosive detonations. The direct applicability of the equations to large marine mammals is particularly questionable, given that the largest animals from which data are available are sheep.

Based on the Yelverton (1981) equations, an impulse of 74 Pascal•seconds would be safe for a 7 to 9 pound (3 or 4 kilogram) marine mammal, i.e., even for newborn calves of the smallest dolphins in the Sea Range area. His equations suggest that no damage would occur to a 220 pound (100 kilogram) marine mammal exposed to an impulse of 289 Pascal•seconds or less, and to a 2,200 pound (1,000 kilogram) marine mammal exposed to an impulse of 702 Pascal•seconds or less. The safe level for a human swimmer near the surface is 14 Pascal•seconds (Yelverton 1981), and this could be taken as the magnitude of an absolutely safe impulse for marine mammals. In Section 4.7.2.1-C we use Yelverton's equation to predict the lethal radius for marine mammals resulting from intact missiles and targets hitting the water.

Chaff and Flares

An extensive review of literature, combined with controlled experiments, revealed that chaff and self-defense flares pose little risk to the environment or animals (U.S. Air Force 1997). The materials in chaff are generally non-toxic except in quantities significantly larger than those any marine mammals could reasonably be expected to encounter as a result of chaff use in the Sea Range (potential impacts of chaff and flares are addressed in Section 4.7.2.7). Particulate tests and a screening health risk assessment concluded that concerns about the chaff breaking down into respirable particle sizes are not significant concerns. Effects from inhalation are not considered to be a significant issue since chaff particles do not pass the trachea and would represent a small percentage of the particulates regularly inhaled by animals, particularly at sea where chaff fibers sink. Few animals are expected to suffer physical effects from chaff ingestion, although no information was available concerning the ability of surface or bottom feeding species to process ingested chaff. Chaff-like aluminized mylar strips fed to harp seals, *Phoca groenlandica*, as dietary markers were passed in the feces and the seals remained healthy (J. W. Lawson,

LGL Ltd., unpubl. data). Given the properties of chaff fibers (they are soft, flexible, and inert), skin irritation is not expected to be a problem for marine mammals.

Approximately 15 flare operations occur annually on the Sea Range during current operations. Toxicity is not a concern with self-defense flares because the primary material in flares, magnesium, is not highly toxic (U.S. Air Force 1997), and will normally combust before striking the land or sea surface. There have been no documented reports of wildlife consuming flare materials, and it is unlikely that marine mammals would ingest these materials. The probability of injury from falling dud flares and debris was found to be extremely remote. Although impulse cartridges and initiators used in some flares contain chromium and lead, a screening health risk assessment concluded that they do not present a significant health risk in the environment (U.S. Air Force 1997).

Pinnipeds could ingest chaff fibers or flare debris with food; any effects of this are likely to be short-term and unlikely to cause serious internal damage. Contact with chaff or flare debris is unlikely to cause injury to skin or eyes since contact would not be prolonged. Chaff fibers sink in disturbed water. On land, chaff fibers and flare debris are inert and would not cause entanglement. Also, chaff fibers on land are degraded to respirable particulates, and would not cause injury on inhalation, as they would not pass the trachea and are readily expelled on contact with nasal mucosa.

Cetaceans could ingest chaff fibers or flare debris with food, or baleen of baleen whales could become contaminated with chaff or flare debris. Such effects are likely to be short-term and unlikely to cause serious internal damage to cetaceans. Contact with chaff or flare debris is unlikely to cause injury to skin or eyes since contact would not be prolonged. Flare debris would be encountered in very small quantities and sinks in disturbed water.

Sea otters are unlikely to encounter chaff, as it is not usually released in their nearshore habitat. If a sea otter did ingest chaff fibers or flare debris with food, effects are likely to be short-term and unlikely to cause serious internal damage. Contact with chaff or flare debris is unlikely to cause injury to skin or eyes since contact would not be prolonged, particularly as sea otters groom themselves frequently at the water's surface. Chaff fibers sink in disturbed water, and flare debris would be encountered in very small quantities.

B - Entanglement and Ingestion

Solid debris such as missile and aircraft parts, and floating target components (floatation foam, plastic parts), may be encountered by marine mammals on land or in the waters of the Sea Range. The primary hazards from persistent plastics and other debris to marine mammals are through entanglement (leading to drowning, strangulation, or flesh damage) and injury due to ingestion. Entanglement in man-made debris is a very common source of injury and mortality among marine mammals throughout the world (Kullenberg 1994). All types of material left in the ocean by the military during exercises were assessed for the potential to entangle marine mammals.

Fur seals, especially young animals, have a tendency to investigate any object in the ocean including fishing nets (Shaughnessy and Davenport 1996). Interactions with fishing gear are often associated with attempts by the seals to feed on the fish nets. Seals often insert their heads into any opening, similar to natural "play" (usually done with pieces of kelp or driftwood), and often get entangled (Fowler 1987). Although they frequently can free themselves, sometimes this is impossible. After the Second World War, northern fur seals were observed caught in rubber rings thought to be of military origin (Fowler 1987). The incidence of entanglement of northern fur seals has greatly increased since the mid-1960s

coinciding with increased fishing effort in the North Pacific and Bering Sea. The three types of debris that most often entangle northern fur seals in that area (in order of frequency) are trawl net fragments, plastic packing bands, and string or small lines (Fowler 1987). Almost all pieces of entanglement debris observed on sub-adult, male northern fur seals on shore at St. Paul Island, Alaska, weighed less than 1 pound (0.5 kilogram; Fowler 1987).

Entanglement can increase the energy expenditure of marine mammals. A swimming California sea lion entangled in a piece of net weighing about 1 pound (0.5 kilogram) required an energy expenditure of about four times that of the same sea lion when it was not entangled (Feldkamp 1985). Thus even small pieces of debris can markedly affect an animal.

Entanglement can also cause direct injury and mortality of pinnipeds. Entanglement can cause lacerations, usually on the neck, and subsequent infection of the wounds. Entanglements can cause mortality by starvation (inability to capture prey), strangulation, infection, severed arteries, drowning, increased vulnerability to predation, or a combination of effects (Fowler 1987; Hiruki et al. 1993). Fowler (1987) estimated that about 15 percent of young fur seals from the Pribilof Islands suffered from debris-related mortality. Although he postulated that this may be a principal cause contributing to the current decline in the northern fur seal population on these islands, Fowler's theory does not appear to be supported by the available data (Trites 1992). Within the Point Mugu Sea Range, pinniped entanglement in fishing debris does occur (Stewart and Yochem 1985).

Entanglement in man-made debris, usually fishing gear, is also a problem for cetaceans in many parts of the world. It may be the cause for the population declines reported for some species (Perkins and Beamish 1979; Jefferson and Curry 1994; Trippel et al. 1996; Kirkwood et al. 1997; Stacey et al. 1997).

Entanglement in military-related gear was not cited as a source of injury or mortality for any marine mammal recorded in the NMFS database documenting strandings of marine mammals (and sea turtles) in southern California waters. This database includes some (not all) of the pinnipeds and cetaceans stranded near Point Mugu and on the shores of the Sea Range. The lack of such records is likely the product of the relatively low amounts of military debris that remains on or near the sea surface, and the fact that the potential entanglement hazards associated with cable and parachute assemblies of ship-launched defensive flares have been mitigated by current designs. These are self-scuttling and sink rapidly to the sea floor after cessation of function. Parachute and cable assemblies used to facilitate target recovery are designed to be collected in conjunction with the target during normal recovery operations. However, on infrequent occasions these assemblies cannot be recovered. Floating debris, such as foam floatation material, may be lost from floating target boats, but is inert and will either degrade over time, or wash ashore as flotsam. In any event, it is unlikely that a marine mammal would be injured by contact with, or ingestion of, the relatively small amount of this lightweight material that is dispersed over the broad area of the Sea Range.

Metal fragments disassociated from air- or seaborne targets by ordnance impacts will sink quickly to the sea bottom and likely pose no threat to marine mammals.

Very few pieces of debris with the potential to entangle cetaceans are left in the water during military exercises. It is also unlikely that marine mammals would ingest this material as most of it is designed to sink to the bottom, or will be dispersed over a large area. Therefore, ingestion or entanglement impacts on marine mammals are predicted to be less than significant and are not addressed further in this section.

C - Hazardous Constituents

Hydrocarbon-based Fuels

About 8,800 pounds (4,000 kilograms) of jet fuel and 550 pounds (250 kilograms) of other hydrocarbons were released into waters of the Sea Range in FY95 (refer to EIS/OEIS Section 4.13). *Due to the nature of the exercises, most of these materials would be released in non-territorial waters* (potential impacts from hazardous constituents are addressed in Section 4.7.2.10). Jet fuel is toxic but vaporizes quickly. Assuming that a QF-4 disintegrates on contact with the water, its fuel will be spread over a large area and dissipate quickly. In addition, fuel spills would occur at widely separated locations and times.

Most marine mammals are not very susceptible to the effects of oil and hydrocarbon-based fuels. Whales, phocid seals, and sea lions rely on a layer of blubber for insulation, and oil fouling of the external surface does not appear to have any adverse thermoregulatory effects (Kooyman et al. 1977; St. Aubin 1990; Geraci 1990). However, sea otters, fur seals, and newborn seal pups rely on their fur for insulation and may be more susceptible to effects of contamination by hydrocarbon-based fuels, especially in cold-water conditions.

Cetaceans: Whales rely on a layer of blubber for insulation and oil would have little if any effect on thermoregulation. Effects of oiling on cetacean skin appear to be minor and of little significance to the animal's heath (Geraci 1990). There is no concrete evidence that oil spills, including the much studied Santa Barbara and *Exxon Valdez* spills, caused the deaths of cetaceans (Geraci 1990).

Migrating gray whales were apparently not greatly affected by the Santa Barbara spill. There appeared to be no relationship between the spill and mortality of marine mammals. The higher than usual counts of dead marine mammals recorded after the spill represented increased survey effort (Geraci 1990). The conclusion was that whales were either able to detect the oil and avoid it or were unaffected by it (Geraci 1990).

There was a significant decrease in the size of a killer whale pod resident in the area of the *Exxon Valdez* spill, but no clear cause and effect relationship between the spill and the decline could be established (Dahlheim and Matkin 1994). No effects on humpback whales in Prince William Sound were evident after the *Exxon Valdez* spill (von Ziegesar et al. 1994). There was some temporary displacement of humpback whales out of Prince William Sound. This displacement could have been caused by oil contamination, boat and aircraft disturbance, or displacement of food sources.

Some cetaceans can and sometimes do avoid oil, but others enter and swim through slicks without apparent effects (Geraci 1990; Harvey and Dahlheim 1994). It can be assumed that, if oil contacted the eyes, effects would be similar to those that have been observed in ringed seals (see below). Continued exposure of the eyes to oil could cause permanent damage (St. Aubin 1990).

Whales could ingest oil with contaminated water or food, or it could be absorbed through the respiratory tract. Some of the ingested oil is voided in vomit or feces but some is absorbed and could cause toxic effects (Geraci 1990). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982). Whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982).

In baleen whales, crude oil could coat the baleen and reduce filtration efficiency; however, effects may be reversible within a few days (see Richardson et al. 1989 and Geraci 1990 for reviews). Effects of oiling of the baleen on feeding efficiency appear to be only minor (Geraci 1990).

In summary, cetaceans could ingest spilled fuel or oil with food, or the baleen of baleen whales could become contaminated. Such effects are likely to be short-term and are unlikely to cause serious internal damage to cetaceans. Spills on the Sea Range are small and small amounts of ingested petroleum hydrocarbons are not highly toxic. Also, aviation fuels are volatile and will not remain on the sea surface for long. Contact with oil is unlikely to cause injury to skin or eyes unless contact is prolonged. Some cetaceans appear to be able to detect and avoid oil, but often they do not do so. There is no firm evidence of oil-spill related deaths of cetaceans even in the case of catastrophic spills orders of magnitude larger than those associated with Sea Range activities.

Pinnipeds: The pinniped species found in the Sea Range all give birth to their pups on land. Newborn pups rely on their fur for insulation and do not enter the water until they have built up a layer of blubber for insulation. Newborn seal pups might die if exposed to oil, with the likelihood depending on the weather conditions at the time of fouling.

Reports of the effects of oil spills have shown that some mortality of seals can occur as a result of oil fouling; however, large scale mortality is rare (St. Aubin 1990; *cf.* Loughlin [ed.] 1994). The largest impacts of spills are likely to occur on young hair seals in cold water (St. Aubin 1990). Effects would presumably be less in warm-water situations like the Sea Range. Brownell and Le Boeuf (1971) found no marked effects of oil from the Santa Barbara oil spill on California sea lions or on the mortality rates of newborn pups.

Effects on pinnipeds have not been well studied at most spills because of lack of baseline data and/or the brevity of the post-spill surveys. Intensive and long-term studies were conducted after the *Exxon Valdez* spill in Alaska. There may have been a long-term decline of 36 percent in numbers of molting harbor seals at oiled haul-out sites in Prince William Sound following that spill (Frost et al. 1994). The seals were probably not displaced and the decline probably represented mortality. Harbor seal pup mortality at oiled beaches was 23 to 26 percent, which may have been higher than natural mortality (Frost et al. 1994). There were no data that provided conclusive evidence of spill effects on Steller sea lions (Calkins et al. 1994). Oil did not persist on sea lions themselves (as it did on harbor seals) nor did it persist on their haul-out sites and rookeries (Calkins et al. 1994). Sea lion rookeries and haul-out sites, unlike those used by harbor seals, had steep sides and were subject to high wave energy (Calkins et al. 1994).

Contact with oil on the external surfaces can cause increased stress and can irritate the eyes of seals (Geraci and Smith 1976; St. Aubin 1990; Lowry et al. 1994). These effects seem to be temporary and reversible, but continued exposure of the eyes could cause permanent damage (St. Aubin 1990).

Pinnipeds can also ingest oil if their food is contaminated. Oil can also be absorbed through the respiratory tract (Geraci and Smith 1976; Engelhardt et al. 1977). Some of the ingested oil is voided in vomit or feces, but some is absorbed and can cause toxic effects (Engelhardt 1981). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982, 1985). Nevertheless, seals exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982).

One notable behavioral reaction to oiling is that oiled seals are reluctant to enter the water, even when intense cleanup activities are conducted nearby (St. Aubin 1990; Frost et al. 1994).

Pinnipeds that are under some type of natural stress, such as lack of food or a heavy infestation by parasites, could die as a result of the additional stress of oiling (Geraci and Smith 1976; St. Aubin 1990). Pinnipeds that are not under natural stress would be more likely to survive oiling.

Pinnipeds exposed to heavy doses of fuel oil for prolonged periods of time could die. This type of prolonged exposure could occur if oil reached a bay near a haul-out site. In this situation, pinnipeds might not be able to avoid prolonged contamination and some would die.

Although pinnipeds may have the capability to detect and avoid oil, they apparently do so only to a limited extent (St. Aubin 1990). Pinnipeds may abandon the area of an oil spill because of human disturbance associated with cleanup efforts, but they are most likely to remain in the area of the spill.

In summary, pinnipeds do not exhibit large behavioral or physiological reactions to limited surface oiling, incidental exposure to contaminated food, or to vapors (St. Aubin 1990; Williams et al. 1994). Effects can be severe if seals surface in heavy oil slicks in confined areas or if oil accumulates near rookeries and haul-out sites (St. Aubin 1990). However, aviation fuels are volatile and would not form persistent slicks. Effects on pinnipeds of an oil or fuel spill in open water are likely to be minor. *Fuel spills resulting from the crash of a QF-4 drone are most likely to occur in offshore waters, well away from haul-out sites or breeding beaches.*

Sea Otters: Sea otters do not have a layer of blubber for insulation. They rely on their fur and a high metabolic rate, supported by a prodigious rate of food consumption, to cope with cold water. Contamination with oil mats the fur and destroys its insulative capacity. Oiled otters attempt to remove the oil by grooming. A sea otter could not survive oiling of the entire body (Geraci and Williams 1990). Oiled otters ingest oil while they groom in attempts to remove the oil. They also suffer heat loss, lose valuable feeding time, and may sustain severe internal damage such as pulmonary emphysema, stress induced gastric erosions, and internal hemorrhage (Lipscomb et al. 1994). Eventually these stresses overwhelm the otters; they go into shock and die (Lipscomb et al. 1994).

About 4,000 sea otters are estimated to have died following the *Exxon Valdez* spill (Ballachey et al. 1994). Oiled otters that survived, and otters that escaped oiling, had higher than normal mortality rates. These effects may have occurred as a result of the pelts of some otters becoming oiled through contact with oil-contaminated food and/or through ingestion of oil with food (Ballachey et al. 1994). Sea otters that had been oiled, rehabilitated, and released also showed abnormally high mortality rates and low reproductive rates (Ballachey et al. 1994).

The sea otter is the marine mammal that is most likely to suffer immediate and long-term injury or death from exposure to oil (Geraci and Williams 1990). One can assume that most of the otters that come into contact with a spill are likely to die, if not immediately then at some later time. The volatility of aviation fuel would reduce its potential effects relative to those of heavier oils. However, sea otters remain close to the shore in territorial waters whereas spills of fuel are most likely to occur offshore in non-territorial waters. The potential for interaction between sea otters and fuel spills associated with Sea Range operations is remote.

Other Constituents

About 2,120 pounds (961 kilograms) of missile propellants, consisting of ammonium perchlorate, hydroxyl-terminated polybutadiene, mixed amine fuel, inhibited red fuming nitric acid (an oxidizer),

mixtures of boron, potassium nitrate, and powdered aluminum were released into the water from Sea Range operations in FY95. As in the case of jet fuel, this material is released at different times and locations and quickly dissipates in the air or on impact.

Other Materials

Non-recoverable Military Products: About 1,690 pounds (768 kilograms) of batteries are released per year in the Sea Range. They contain chemicals such as potassium hydroxide electrolyte, lithium, lithium chloride, nickel cadmium, lead, and sulfuric acid. In addition, aluminum, iron, steel, and concrete are released during naval exercises.

Concrete, aluminum, iron, lithium, lead, and steel are chemically innocuous at concentrations found naturally and arising from military operations. Magnesium is abundant in seawater (average concentration 0.135 percent) and, therefore, is not of concern. Considering the area over which the missile propellants and battery fluids are spread, the quantities will dilute to concentrations too low to warrant concern.

Various munitions, markers, sensors, and other materials are expended during training activities. There is also a potential for loss of materials that are intended to be reused. Potential effects include degradation of air quality from gaseous and particulate emissions from combustion gases and smoke markers, and degradation of water and sediment quality from contaminants introduced to the ocean. The materials involved are diverse including lead, copper, aluminum, steel, nylon, ABS, styrofoam and various plastics, lithium, depleted uranium (no longer used), zinc, organometallic compounds (e.g., lead styphnate), fiberglass, antimony, manganese, magnesium, cadmium, strontium, tungsten, and iron.

The composition and behavior in the environment of some expendables has changed significantly and positively. Most notable is the recent replacement of depleted uranium (DU) ammunition with tungsten ammunition for the CIWS. Materials used in sonobuoy construction, and the environmental design of sonobuoys, have also changed as the result of a recently introduced U.S. military specification.

Of the materials identified, aluminum, iron, and steel are innocuous chemically. Magnesium is abundant in seawater (average concentration 0.135 percent) and, therefore, is not of concern.

Lithium, manganese, antimony, strontium, and mercury are potentially toxic, but the quantities introduced annually into the Sea Range environment are relatively small. Considering the area over which these materials are spread, the quantities involved are too low to warrant concern. The remaining substances, zinc, copper, and lead, are relatively inert. They are slowly released into water (lead and copper) or are rapidly diluted (zinc). Lead and copper become attached to suspended particulates and accumulate in sediments. Detonation and combustion by-products are rapidly diluted to naturally occurring levels, as reviewed in detail below.

The majority of the zinc associated with expendable materials used in the Sea Range is in the form of zinc alloys and coatings. Zinc corrodes rapidly in sea water and is frequently used in sacrificial anodes and coatings to provide corrosion protection. A typical warship may have 6 to 28 tons (5 to 25 metric tons) of zinc anodes, which must be replaced at regular intervals. Average concentrations of zinc in seawater are less than 10 parts per billion. In reducing sediment environments, zinc is effectively immobilized in the form of organic and sulfide complexes. Exposed zinc materials are expected to corrode and rapidly dilute to background concentrations. Zinc can bioaccumulate, but is not known to biomagnify. The form of the materials containing zinc is unpalatable to marine life and, therefore,

unlikely to be ingested. The estimated annual rate of input of zinc from expendables is reviewed in EIS/OEIS Sections 3.13 and 4.13, and is distributed over a large area. Therefore, it is expected that there would be negligible effects on water and sediment zinc concentrations from expendable materials employed in the Sea Range.

Sources of copper include probes, sonobuoy cable, electronic payloads of sonobuoys, targets, signal devices, and ammunition. The majority of the copper associated with expendable materials used in the Sea Range is in the form of coated copper wire and coated electrical circuitry. The plastic coatings can be expected to be very long-lived on the seabed because of the relatively low temperatures and absence of ultra-violet light. While no data could be found on the length of time such coatings may persist, it is reasonable to estimate that the coatings will last for several decades with only a small portion of the copper exposed to seawater at fracture points. Assuming that the copper was exposed, the corrosion rate is likely to be about 0.002 inches (50 microns) per year (Shreir 1977). If buried in an anoxic sediment zone, the copper will not be oxidized and will not be bioavailable. As with lead, dissolved copper will tend to absorb onto suspended particulates and accumulate in sediments. The estimated annual rate of input of copper is reviewed in EIS/OEIS Sections 3.13 and 4.13, and is distributed over a large area. Therefore, it is expected that there would be negligible effects on water and sediment copper concentrations from expendable materials employed in the Sea Range.

Lead is very inert and will corrode and dissolve very slowly in seawater. Under oxygenated conditions the rate of dissolution is 0.0003 to 0.001 inches (8 to 30 microns) per year (Smith 1990). Under anoxic conditions a surface layer of sulfide forms of extremely low solubility that inhibits further corrosion. Sources of lead include bullets, weights, ballast, and batteries. Lead in the form of lead chloride (e.g., older sonobuoy batteries) is not soluble. Lead from any of these sources which does dissolve will tend to associate with suspended particulates and accumulate in sediments. The estimated annual rate of input of lead is on the order of a few metric tons and is distributed over a large area. Lead concentrations were investigated during a study of Canadian Forces marine ranges, which involved higher rates of lead input within an area smaller than the Point Mugu Sea Range (Pacific Marine Technology Center 1995). The study demonstrated that lead concentrations in the sediment were within the range of results reported for uncontaminated coastal areas, and well below North American ocean dumping and sediment management standards for lead. Therefore, it is expected that test and training operations would have negligible effects on concentrations of lead in water and sediment in the Sea Range.

About 1,690 pounds (768 kilograms) of batteries are released in the Sea Range per year. Their chemicals include a variety of potassium hydroxide electrolyte, lithium, lithium chloride, nickel cadmium, lead, and sulfuric acid. In addition, aluminum, iron, steel, and concrete are released. Concrete, aluminum, iron, lithium, lead, and steel are chemically innocuous (harmless) at concentrations found naturally, and arising from the types of military operations evaluated in the EIS/OEIS. Magnesium is abundant in seawater (average concentration 0.135 percent) and, therefore, is not of concern. Considering the area over which the missile propellants and battery fluids are spread, the quantities dilute to concentrations too low to warrant concern.

Detonation and Combustion By-Products: The majority of detonation and combustion by-products (more than 99 percent) are gaseous and smoke emissions that are dispersed in the air. Dilution is rapid. Jacques Whitford Environmental Ltd. (1995) estimated that dilution by a factor of 1000 was achieved within the first minute following firing.

By-products of pyrotechnics and munitions are diverse and include metal oxides, salts, and acids. Cyanide acid and hydrocyanic acid are trace by-products of some explosives and propellants, such as

cordite and black powder, used in ammunition. HC smoke pots produce hexachloroethane smoke, which is toxic. Lead styphnate is an organometallic compound in Types A, C, and D primer used in various types of ammunition that, on detonation, produces lead by-products that can be of concern for inhalation.

The concentration of detonation and combustion by-products reaching the ocean is not known, but it is most probable that concentrations are so low as not to pose a concern to marine life.

Discharges from Vessels: Vessel presence and activity in an area results in many types of discharges. These include the following: deck run-off and wash water, oil and grease leakage at shaft seals and seals on cooling water lines, leaching of toxic substances from anti-fouling coatings, corrosion of sacrificial anodes, generator and machinery exhaust, discharges of ballast water, boiler wash water, and gray water from laundry, kitchen, and sewage treatment systems. Such discharges from Navy vessels engaged in test and training exercises are not appreciably different from discharges incidental to other vessel activity in the Sea Range. The Sea Range is open to commercial and other vessel traffic. Navy operations constitute only about 9 percent of the total vessel activity within the Sea Range (see EIS/OEIS Section 3.3.2.2).

Contaminants associated with these discharges include petroleum hydrocarbons and Polycyclic Aromatic Hydrocarbons (PAHs), nutrients, surfactants, zinc and other metals, and organotin compounds. All of these discharges are either chronic releases of small quantities or brief discharges that are limited to open waters with high circulation. Dilution rates are high and the quantities involved are small.

Ballast waters discharges are of particular concern because of the potential to introduce non-indigenous species into an area by discharging ballast water taken on at a remote location. To mitigate this concern the International Maritime Organization (IMO) has promulgated guidelines. These guidelines essentially state that, if discharge of potentially contaminated ballast water is required, the water shall be off-loaded no less than 12 NM (22.2 kilometers) from shore and clean sea water taken on and discharged two times prior to entry within 12 NM (22.2 kilometers) of shore.

Discharges from Aircraft: Engine exhaust emissions from helicopter and fixed-wing aircraft (including drones) introduce gaseous and particulate pollutants into the atmosphere. It is anticipated that gaseous emissions will be diluted by a factor of 1,000 within a few minutes and by a factor of 1 million within 1 hour. The ultimate fate of particulate emissions is likely to enter the water spread out in a large area and to gradually sink and become incorporated into sediments.

There is some evidence to support concerns about gaseous and particulate emissions from aircraft in the vicinity of airports with high traffic levels. However, aircraft activity associated with military training occurs at a relatively low frequency in the Sea Range and occurs over a large area. Any impacts would be short-term and local. The impacts of aircraft exhaust emissions on marine mammals are judged to be negligible.

4.7.2 No Action Alternative

The No Action Alternative includes air-to-air, air-to-surface, surface-to-air, surface-to-surface, and subsurface-to-surface operations, littoral warfare training, and FLEETEXs. These activities involve aircraft and missile overflights, ship and boat movements, target launches and overflights, release of chaff and flares, and release of unspent fuel and debris. In the following sections, activities common to all exercises are evaluated and then an overall evaluation of each operation provided. Some of the detailed calculations are presented in Appendix B. A summary of impacts on marine mammals is

provided in Table 4.7-2. Impacts of the No Action Alternative are evaluated in this section. Impacts of the Minimum Requirement Alternative and Preferred Alternative are evaluated in following sections.

4.7.2.1 Impacts of Common Activities

A - Aircraft and Missile Overflights

Airborne Noise

Based on an analysis of data reported in Burgess and Greene (1998), Vandal target launches from San Nicolas Island produce a 100 dBA acoustic contour that extends an estimated 13,986 feet (4,263 meters) from its launch track (Figure 4.7-7). The contour defines the area within which pinnipeds may sometimes react strongly (i.e., stampede into the water) when exposed to prolonged airborne sounds. The Vandal launch sound could be received for several seconds and, to be conservative, is considered to be a prolonged rather than a transient sound. Harbor seals, California sea lions, and elephant seals that haul out on the western end of San Nicolas Island are within the perimeter of the 100 dBA contour shown on Figure 4.7-7. Targets reach transonic speed by the time they cross the western end of the island at moderate altitude, and accelerate to supersonic speed west of the island. The number of hauled-out pinnipeds within the 100 dB contour was estimated from census data obtained during aerial and ground-based surveys conducted during 1989 to 1993 (M. Lowry, NMFS unpubl. report). This estimate represents the average population size, including adults, subadults, and pups. All three species present are seasonal breeders. During their late January to early February breeding season, an average of 4,671 elephant seals were within the 100 dB contour. The average number of California sea lions in this area ranged from 21,060 during their July breeding season to 7,895 during the period from October to April. About 60 percent of the harbor seals on San Nicolas Island, or about 280 individuals, occur within this area (G. Smith, Point Mugu Environmental Division, personal communication, 1998). Pinnipeds sometimes react strongly (stampede into the water) when exposed to prolonged airborne sounds with received levels at or above 100 dBA (see Section 4.7.1.1).

No data are available on these animals' responses to Vandal or similar launches. The number of these pinnipeds that might actually be disturbed to the extent that they might flush into the water is undoubtedly less than the total population estimates. Sonic booms have resulted in a startle reaction involving some movement into the water, and noise from a distant exploding rocket caused most sea lions, but not elephant seals, to stampede into the water (Stewart et al. 1993; Section 4.7.1.4-A). Observations of other potentially-disturbing noise events in the area suggest that pinnipeds often do not react strongly to prominent sounds (Greene et al. 1998a). In addition, there are only about eight Vandal launches per year under current conditions. It is not known whether some individual pinnipeds stampede into the water in response to Vandal launches; if so, there is some risk of injury or mortality of pups.

At present, it is not possible to estimate the numbers of seals that are disturbed by Vandal launches or to estimate pup mortality, if any, resulting from stampedes into the water. However, there has been rapid growth in resident pinniped populations despite such launch operations (see Section 3.7.4 of this report). This could imply that there is little if any mortality or serious injury of pups due to stampedes into the water during Vandal or similar launches. Thus, impacts of Vandal launches on pinniped populations on San Nicolas Island are less than significant whether or not there are any adverse effects on individual pinnipeds.

Table 4.7-2. Marine mammal impact summary matrix.[1]

Alternative	Impact Conclusions	
	NEPA (On Land→ Territorial Waters)	**EO 12114** (Non-Territorial Waters)
NO ACTION ALTERNATIVE	There is a low probability in any one year that any marine mammal is injured or killed by intact missile impacts or shock waves (0.0004), inert mine drops (0.0005), or falling debris from intercepts (0.0007) in territorial waters (Table 4.7-3). The probability that a threatened or endangered species is hit approaches zero. Impacts are less than significant. Small numbers of marine mammals (2.0 per year) experience TTS with no biological consequences in territorial waters (Table 4.7-3). The likelihood of any individual animal experiencing TTS more than once per year approaches zero. Impacts are less than significant. Pinnipeds on San Nicolas Island show little reaction to most transient sounds, but on rare occasions some pinnipeds stampede into the water. Pinniped populations near the launch sites and around the entire island are expanding. Pinnipeds at Point Mugu are not exposed to sound levels that could cause disturbance. Population level impacts are less than significant.	*There is a low probability in any one year that any marine mammal is injured or killed by intact missile impacts or shock waves (0.0009), or falling debris from intercepts (0.001) in non-territorial waters (Table 4.7-3). The probability that a threatened or endangered species is hit approaches zero. Impacts are less than significant.* *Small numbers of marine mammals (2.1 per year) experience TTS with no biological consequences in non-territorial waters (Table 4.7-3). The likelihood of any individual animal experiencing TTS more than once per year approaches zero. Impacts are less than significant.*
MINIMUM REQUIREMENT ALTERNATIVE (This alternative includes impacts identified for the No Action Alternative.)	Increased debris would have a negligible effect on the overall probability of a marine mammal being injured or killed by intact missiles and falling debris hitting the water (Table 4.7-7). Small numbers of marine mammals (5.2 per year) may experience short-term TTS with no biological consequences (Table 4.7-7). Impacts would be less than significant. Pinnipeds on San Nicolas Island would show little reaction to nearshore intercepts. San Nicolas Island construction would not affect pinniped haul-out sites. Otherwise same as for "No Action Alternative." Population-level impacts would be less than significant.	*Increased debris would have a negligible effect on the overall probability of a marine mammal being injured or killed by intact missiles and falling debris hitting the water (Table 4.7-7).* *Small numbers of marine mammals (2.3 per year) may experience short-term TTS with no biological consequences (Table 4.7-7). Impacts would be less than significant.*

Table 4.7-2. Marine mammal impact summary matrix (continued).

Alternative	Impact Conclusions	
	NEPA (On Land→ Territorial Waters)	**EO 12114** (Non-Territorial Waters)
PREFERRED ALTERNATIVE (This alternative includes impacts identified for the No Action Alternative.)	Increased debris would have a negligible effect on the overall probability of a marine mammal being injured or killed by intact missiles and falling debris hitting the water (Table 4.7-8). Small numbers of marine mammals (5.2 per year) may experience short-term TTS with no biological consequences (Table 4.7-8). Impacts would be less than significant. Some of the pinnipeds on western San Nicolas Island may react to some additional launches. Population-level impacts would be less than significant. Use of the beach launch pads at NAS Point Mugu and construction at San Nicolas Island would not affect pinniped haul-out sites. Additional launches from San Nicolas Island would have no long-term impacts. Received sound levels at the Mugu Lagoon haul-out site would remain below the disturbance threshold. Impacts would be less than significant.	*Increased debris would have a negligible effect on the overall probability of a marine mammal being injured or killed by intact missiles and falling debris hitting the water (Table 4.7-8).* *Small numbers of marine mammals (2.9 per year) may experience short-term TTS with no biological consequences (Table 4.7-8). Impacts would be less than significant.*

[1] Numbers have been rounded within this table for readability.

Missiles and subsonic BQM targets are occasionally launched from the west end of San Nicolas Island. During a launch of one of the larger and non-standard types of missiles from that site, pinnipeds near the launch site stampeded into the water. According to the criteria outlined in Section 4.7.1.1, this constitutes a potentially adverse impact on individual pinnipeds. However, it is not known whether any pinnipeds have been injured or killed during such events. Launches of this type are very infrequent (less than one per year), and pinniped populations at San Nicolas Island are increasing. Impacts of launches from the west end of San Nicolas Island on pinniped populations of that island are less than significant despite infrequent cases of potential disturbance to individual pinnipeds.

BQM-34S target launches from NAS Point Mugu produce a 100 dBA acoustic contour that extends an estimated 4,500 feet (1,370 meters) on either side of its launch track (Burgess and Greene 1998). The harbor seals that haul out in Mugu Lagoon are beyond the perimeter of this contour (approximately 2 miles [3.2 kilometers] away), and thus are unlikely to be disturbed. In addition, the BQM-34S target departs the launch site rapidly, in a direction heading away from the Mugu Lagoon haul-out area. Also, these harbor seals are exposed frequently to other types of man-made sounds. Any sound exposures from the BQM-34S target launch are transitory. Impacts of BQM-34S launches on marine mammals at Point Mugu are less than significant.

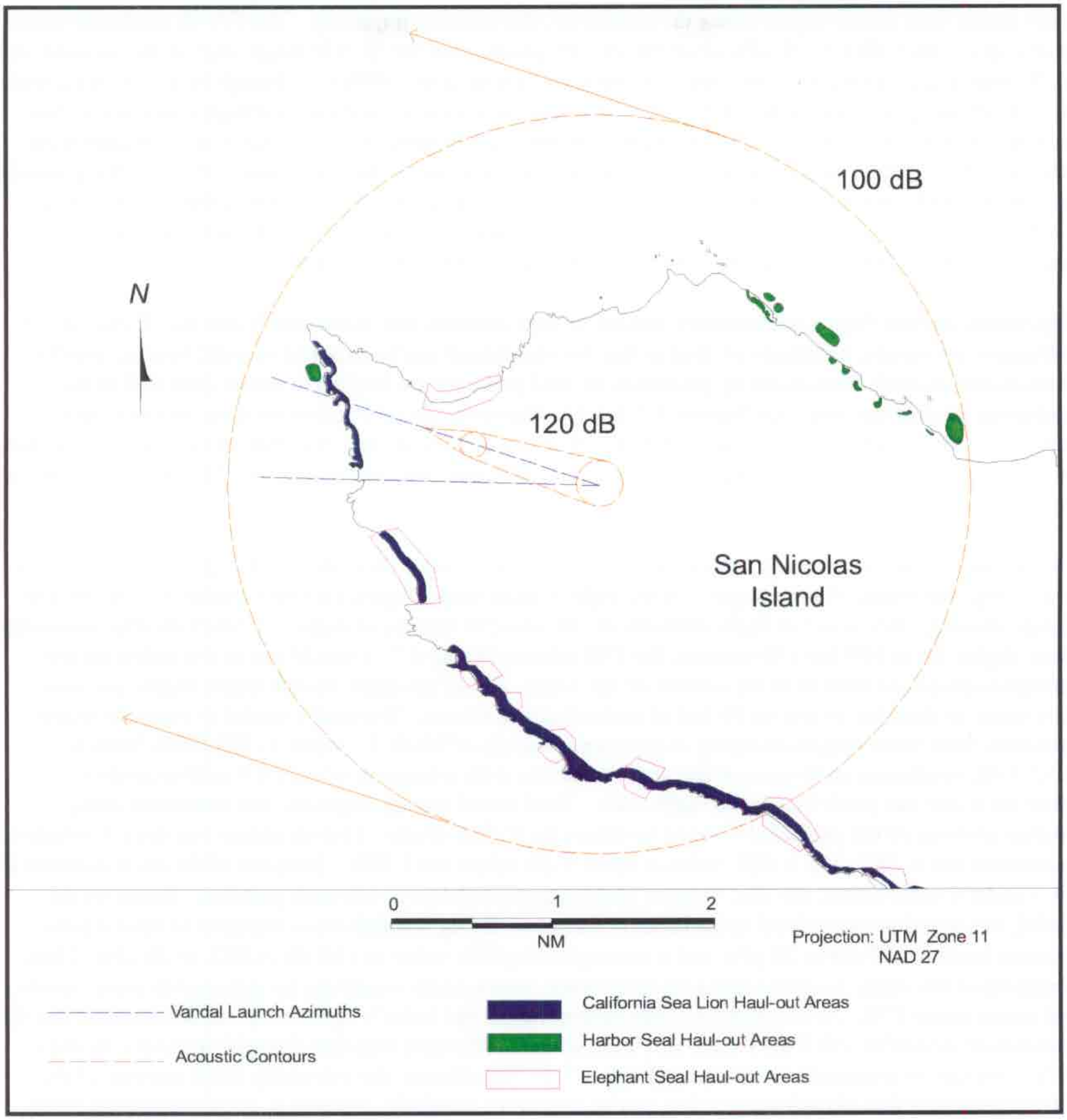


Figure 4.7-7
The 100 and 120 dB re 20 µPa acoustic contours for Vandal target launches from San Nicolas Island on an A-weighted sound exposure level (SEL) basis.

SLAM FA-18 captive carry overflight tests at San Nicolas Island exposed pinnipeds at haul-out areas to more sound than would flights along the normal SLAM exercise trajectory. The FA-18 produced sound levels up to 108.8 dBA re 20 μPa when the aircraft passed over the SLAM target area on the western end of the island at an altitude of 500 feet (150 meters) (Greene et al. 1998a). Although received levels from several aircraft passes exceeded 100 dBA, there were no responses to these overflights that would have an adverse effect on seals. (A small proportion of the seals became alert, but this is not considered an adverse effect.) The lack of a notable response was perhaps due to the acclimatory effect of the gradually increasing levels of sound during successive overflights at progressively lower altitudes (Greene et al. 1998a) plus the transient nature of the sounds. The impacts of current low-level subsonic overflight operations on marine mammals on San Nicolas Island are less than significant.

Supersonic aircraft flights are normally limited to high altitudes and overwater locations. However, on infrequent occasions, pinnipeds on land at San Nicolas Island can be exposed to sonic booms, usually from distant aircraft. Reactions by pinnipeds on land probably are limited to minor alert and startle responses most of the time (see Section 4.7.1.4-A). However, on rare occasions some animals may stampede into the water. It is possible that this could cause injuries to a few individuals, but this has not been documented on the Sea Range. Any effects on pinniped populations are less than significant, given the increasing population sizes.

The strongest noise originating from an aircraft or missile in flight over the Sea Range is produced by a low-flying supersonic Vandal target. Of the eight Vandal target flights currently conducted on the Sea Range annually, two occur at flight altitudes of 100 feet (30 meters) or higher. Conservatively assuming these flights are at 100 feet (30 meters), the TTS criteria (Table 4.7.1) would not be exceeded for any pinniped species on land or at the surface of the water. Six of the eight Vandal target flights per year may occur at altitudes as low as 20 feet (6 meters) above the sea. We used a model to estimate sound pressures from these targets traveling at supersonic speeds of Mach 2.1 (refer to EIS/OEIS Section 3.3.2.1-B), producing an N-wave at the water's surface with a duration of only 4.8 milliseconds as received at any one point below the flight track. Total sound energy exposure was estimated using Fourier analysis of the predicted N-wave to obtain the F-SEL levels. This spectrum was then A-weighted to estimate the A-SEL; the A-SEL value is about 9 dB below the F-SEL. Because of the short duration of the Vandal's sonic boom, the SEL value is much reduced relative to the peak pressure. Based on the model, the sound pressure level in air beneath these low-flying Vandals was estimated to have a peak pressure level of 177 dB re 20 μPa, and a corresponding SEL value of 139 dB A-SEL re 20 μPa. Thus, pinnipeds at the water's surface and with their heads above water would not be exposed to sound levels that might cause TTS. At one foot (30 centimeters) below the water's surface, the model predicts that the sound level would be 158.4 dB F-SEL re 1 μPa, which is also less than that thought necessary to elicit TTS in whales or pinnipeds underwater (Table 4.7-1). In addition, the extremely rapid passage of the Vandal targets at this altitude means that marine mammals would be exposed to increased sound levels for only very short time intervals, and they would be expected to exhibit no more than brief startle responses. Low-flying Vandal targets are expected to have less than significant impacts on marine mammals within the Sea Range.

Overflights of other targets and missiles are usually at altitudes greater than 100 feet (30 meters), and sound produced by those targets is weaker than that from the Vandal. Overflights by aircraft are normally at altitudes of at least 1,000 feet (305 meters). Therefore, none of the transitory noises produced during aircraft or missile overflights at these altitudes are expected to exceed the acoustic disturbance criteria for marine mammals at the surface of the water. Any changes in behavior or distribution of marine mammals at the water's surface in response to the sound of an aircraft such as the FA-18 flying at 200 feet (60 meters), which produces noise levels above the 100 dB aerial disturbance

criteria (refer to Section 3.3 of the EIS/OEIS), would be transitory and negligible. Although launches and overflights may cause behavioral disturbance to some pinnipeds on land, the impacts of overflights on pinnipeds on land, or in the sea with their heads above the water surface, are less than significant.

Underwater Noise

Sound does not transmit well from air to water (Appendix C). The strongest noise produced by an aircraft or missile in flight would be produced by a Vandal target. At the minimum planned flight altitude of 20 feet (6 meters), TTS criteria would not be exceeded for any marine mammal species at or below the water's surface (based on Section 3.3.2.1 of the EIS/OEIS). If Vandal flights did occur below the minimum altitude, some marine mammals may experience mild TTS. However, these flights are infrequent (approximately eight times per year) and the likelihood of any individual animal experiencing even mild TTS more than once per year approaches zero. This level of exposure has no biological consequences and impacts are less than significant.

Overflights of other missiles and aircraft, all of which are less noisy than the Vandal, are at altitudes higher than 60 feet (18 meters). Therefore, none of the aircraft or other missile overflights are expected to exceed the TTS criteria for marine mammals in water. The sounds produced by supersonic aircraft or missiles may cause temporary changes in behavior or distribution of some marine mammals in the upper water column. These effects would be transitory. The impacts of aircraft and target overflights on marine mammals under the surface of the water are less than significant.

Submarine missile launches associated with subsurface-to-surface operations are a source of underwater and aerial sound during booster operation and in flight immediately following water emergence. In addition, these subsurface launches are sources of potential underwater noise as debris or the intact missile hit the water upon termination of the missile flights. Test launches of a water slug to simulate a torpedo launch are "detectable" within a 1.1 mile (1.8 kilometer) radius (Department of National Defence 1995). However, these launches produce only transient sound events.

No subsurface to surface missiles were fired during Sea Range operations in FY95. Given the low number of missile launches from submarine platforms, it is likely that the sounds produced by these launches will cause no more than temporary changes in behavior or distribution of some marine mammals in the upper water column. These effects would be transitory. The impacts of submarine missile launches on marine mammals in the Sea Range are less than significant.

B - Ship Activities

Ships that are part of proposed Navy activities produce sufficient underwater noise to cause short-term changes in baleen whale and sperm whale behavior, and localized displacement of these whales, if the ships approach the whales. Reactions are most pronounced if the ships are moving rapidly and either directly toward the whales or with variable course and speed (Richardson et al. 1995a). These whales may react to multiple vessels working in the same area at longer distances than they would react to a single vessel (Koski and Johnson 1987; Richardson et al. 1995a). Individually identifiable bowhead whales displaced from a feeding area by vessel disturbance have been observed to return and resume feeding within one day (Richardson 1987; Richardson and Malme 1993). Also, baleen and sperm whales often show little reaction to ships or boats if the vessel is moving slowly at constant speed on a constant course. While on the Sea Range, Navy vessels spend only a minority of their time traveling at high speed and/or on variable courses, and will not normally continue to operate at the same location for longer than the time required to transit through that area. Also, Navy vessels account for only about 9 percent of the

vessel traffic on the Sea Range (EIS/OEIS Section 3.3.2.2). The Sea Range is open to commercial and private vessel traffic and is widely used by non-Navy vessels.

Therefore, sperm whales and baleen whales, such as the blue or fin whales that occur west of San Nicolas Island in summer (see Section 3.7.2.2 of this report), may sometimes be displaced temporarily by approaching Navy vessels, but these whales are not likely to be deterred from any one area for more than one to two days. The number of baleen or sperm whales that may be affected is highly variable, but any disturbance is temporary and is not considered to be biologically significant. Impacts of disturbance to baleen whales and sperm whales by Navy ships and boats operating on the Sea Range are less than significant.

There is no evidence that occasional ship and boat traffic causes biologically significant disturbance to pinnipeds or dolphins in open water (Richardson et al. 1995a). Harbor porpoises often show local avoidance of vessels, but harbor porpoises are mainly confined to nearshore waters inshore of the northern part of the Sea Range where Navy vessel traffic is infrequent. Dolphins frequently *approach* ships to ride the bow wave. Any impacts of disturbance from ships and boats on pinnipeds and dolphins are less than significant.

On infrequent occasions, whales and ships collide, resulting in injury or death to the whale. Most reports of ship collisions with marine mammals have involved baleen and sperm whales, but bottlenose dolphins also have been struck (Richardson et al. 1995a). Slow-moving species, especially the right whale and gray whale, are most likely to be struck by ships. There have been no reports of collisions with marine mammals on the Sea Range (S. Schwartz, Point Mugu Environmental Division, personal communication, 1998). In assessing the likelihood of collisions on the Sea Range, it is relevant to consider the following: baleen and sperm whales often try to avoid approaching vessels, the limited amount of Navy vessel traffic on the Sea Range as compared with commercial vessel traffic, the fact that much of the time the Navy vessels on the Sea Range do not operate at high speed, and the absence of reported collisions on the Sea Range. Given this, it is unlikely that a marine mammal would be injured or killed by collision with a Navy vessel during any given year. Because of the rarity of the northern right whale (the species least able to avoid ships) on and near the Sea Range (see Section 3.7.2.2), the probability of a collision with this highly endangered species approaches zero. Although the possibility of a collision between a marine mammal and Navy vessel conducting Sea Range operations cannot be excluded, the frequency of collision is likely very low and effects on marine mammal populations are less than significant.

C - Missile and Target Impacts

Missile and Target Debris

To estimate the number of marine mammals that would be injured or killed by falling debris fragments from missiles or targets in the Sea Range, we estimated the effective surface area of the debris fragments in each part of the Sea Range. We assumed that surface area struck would be equal to the total surface area of the intact missiles and targets multiplied by the number of missiles and targets of five categories that fell within that part of the Sea Range in FY95 (see Appendix B). The subdivisions of the Sea Range considered in this analysis were the strata that were used in calculating marine mammal densities in different parts of the Sea Range (see Figure A-1 in Appendix A). We multiplied the effective debris area by the average marine mammal density for the stratum in question to obtain estimates of the numbers of marine mammals likely to be struck by debris fragments. Only the fraction of the marine mammals expected to be at the surface at any given time were considered in this calculation. We totaled the numbers of marine mammals likely to be struck by debris fragments for all strata to derive an estimate for

the total impact of debris fragments on marine mammals in the Point Mugu Sea Range. The procedures used are described in more detail in Appendix B, "Estimates of Numbers of Marine Mammals at Sea that Might Be Injured or Killed."

Based on operations in the Sea Range during FY95, an estimated 0.002 marine mammals per year are hit by debris from a missile or target (Table 4.7-3; see also Tables B-1 and B-2 in Appendix B). This is equivalent to one serious injury or death in approximately 500 years. Of these, 0.0007 mammals per year would be in territorial waters, *and 0.001 animals per year in non-territorial waters* (Table 4.7-3). Many pieces of debris would have kinetic energy less than the human hazard threshold of 11 foot-pounds (see Section 4.7.1.5-A), so the calculated numbers of mammals that might be injured are overestimates. Even in the rare event that a marine mammal was seriously injured or killed, the impact on the population would be less than significant unless it was a rare and endangered species.

Table 4.7-3. Numbers of marine mammals exposed to injury, mortality, or Temporary Threshold Shift per year as a result of objects striking the water surface during current operations[1]. For detailed calculations, see Tables B-1 and B-2 in Appendix B.

Source of Mortality or Injury	Numbers of Marine Mammals Exposed		
	Territorial Waters	*Non-territorial Waters*	Total
Injury or mortality from missile debris	0.00069	*0.00138*	0.00207
Injury or mortality from CIWS rounds	< 0.00001	*< 0.00001*	< 0.00001
Injury or mortality from inert mine drops	0.00047	*0.00000*	0.00047
Injury or mortality due to missile impact or shock waves	0.00042	*0.00085*	0.00127
Exposure to impulses causing Temporary Threshold Shift	1.95625	*2.09828*	4.05453
Intact missile and target shock waves	1.94033	*2.09345*	4.03378
CIWS gun noise[2]	0.01592	*0.00483*	0.02075
Low-flying vandal targets	0.00000	*0.00000*	0.00000

[1] Numbers included in the text have been rounded for readability.
[2] Applies only to seals with their heads above water.

Rare and endangered species make up an estimated 0.4 percent of the marine mammals in the Sea Range throughout the year based on the normalized densities described in Section 3.7. Therefore, the probability of a rare and endangered species being seriously injured or killed by falling debris approaches zero (approximately 0.00001 animals per year).

The impact of pieces of debris from missiles and targets on marine mammals is less than significant.

Intact Missiles and Targets

Intact missiles and targets can hit the water with sufficient force to injure or kill marine mammals at close range, particularly small individuals. This occurs through blast-like effects. Impulse, measured in Pascal•seconds, is the physical measurement that best characterizes the likelihood and severity of such effects (see Section 4.7.1.5-A).

At somewhat greater distances from the impact point, the strong noise pulse produced by an intact missile or target hitting the water could also produce TTS. The physical measurement best characterizing the likelihood of TTS is Sound Exposure Level (SEL) in decibels (refer to Appendix C).

Very strong impulses produced when high-speed large vehicles hit the water could affect marine mammals well below the surface of the water (Figure 4.7.8). Understanding the propagation of shock waves and pressure from a high-speed contact with water is a very complicated modeling task. The effects of the rate of pressure change ("rise time") from such an event on hearing and on tissue trauma are not well known. A full evaluation of this issue would require a more detailed analysis of the physics of the process of high-speed objects hitting the water, as well as a better understanding of the resulting effects on the auditory and other organs of marine mammals. Both of these are beyond the scope of this assessment.

We estimated effects by creating five categories of vehicles (Table 4.7-4) based on their mass, surface area, and speed if they were to strike the water's surface. For simplicity, these are categorized here as "Phoenix-type" (medium-sized supersonic), "Harpoon-type" (subsonic), "AQM-37/Sidewinder type" (smaller supersonic), Vandal, and "AltAir-type" (larger ballistic missiles). For the estimated proportions of launched vehicles that would hit the water within the Sea Range in one piece, we assumed a scenario where 100 percent of the Vandal-type targets and 17.5 percent of other targets would land in one piece. We further assumed that 50 percent of the AltAir-type and 25 percent each of the Phoenix-, Harpoon- and AQM-37/Sidewinder-type missiles would hit the water intact.

Table 4.7-4. Numbers of intact missiles and targets expected to impact the water surface within the Point Mugu Sea Range, subdivided into five categories.

	Medium-Sized Supersonic	Subsonic	Small Supersonic	Vandal	Larger Ballistic
Types of Vehicle Included in Each Category	Phoenix Standard HARM Sparrow Maverick AMRAAM Hawk	Harpoon SLAM BQM-34 BQM-74	AQM-37 RAM (RIM 116A) Sidewinder	Vandal	AltAir SSM Taurus Lance
Vehicle used as Model	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Surface Area of Model (meter^2)	4.79	4.2	2.93	17.09	25.94
Model Vehicle Mass (kilograms)	310	490	80	1,000	2,183
Impact Pulse Length (milliseconds)	1.7	3.4491	0.7343	1.8726	1.0
Peak Impulse (dB re 1 μPa at 1 meter)	258	239	250	260.45	271
Flights in Stratum 4	10.8	6.1	5		0.8
Flights in Stratum 5	86.4	48.6	40.4		6.4
Flights in Stratum 6	10.8	6.1	5		0.8
Flights in Stratum 8	97	44.3	15.5	8	

The numbers of marine mammals being seriously injured or killed during current operations on a yearly basis were estimated. We used Yelverton's (1981) equation to predict the impulses, in Pascal•seconds, that could cause serious injury or mortality to 1 percent of various kinds of marine mammal present. We then used McLennan's (1997) equation and the spreading loss equation presented in Section 4.7.1.2-C to determine the distances from the contact point at which the impulse would diminish to the "1 percent injury/mortality" levels (Table 4.7-5). The results of these calculations were then applied to the numbers of intact missiles and targets hitting the water and to the density of marine mammals in each range stratum where these missiles or targets are expected to hit the water (see Appendix B). Based on this procedure, an estimated 0.13 marine mammals per year are expected to be within the 1 percent injury/mortality radius. About 0.001 marine mammals are expected to be killed or seriously injured per

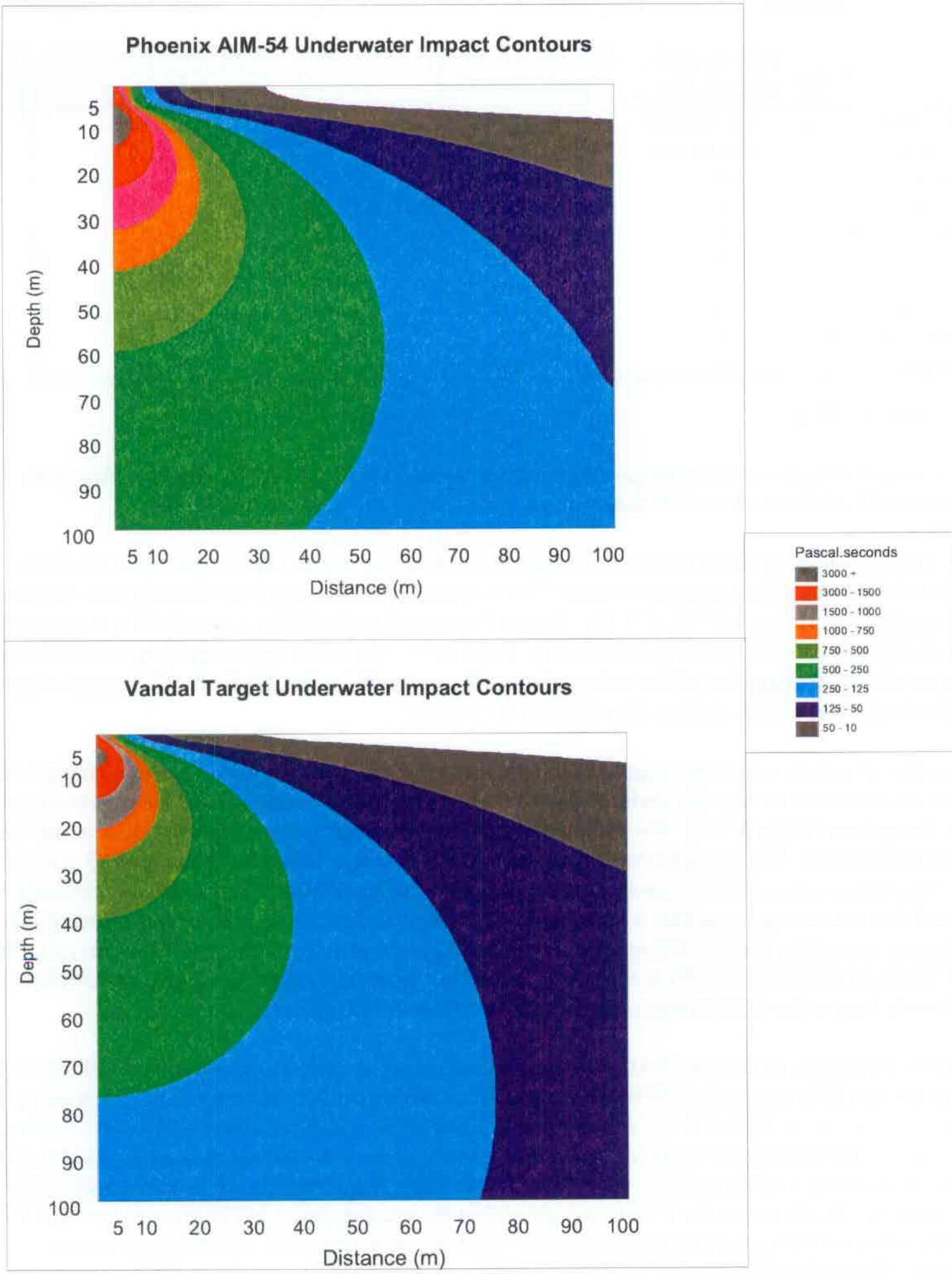


Figure 4.7-8
Underwater impact contours in Pascal•seconds for an intact Phoenix missile and Vandal target hitting the water.

Table 4.7-5. Impulses (in Pascal•seconds) causing one percent mortality of adult marine mammals[1] with the corresponding distances from missile impacts at which those impulses occur.

	Body Weight (kilograms)	One Percent Mortality (Pascal•seconds)	Distance (meters) from				
			Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	11,000-100,000+	1304	1	2	0.1	8	12
Sperm whale	15,000-48,000	1304	1	2	0.1	8	12
Pilot whale	800	1197	1	2	1	8	15
Risso's dolphin	300	819	3	2	1	12	22
Bottlenose dolphin	200	701	3	3	2	14	26
White-sided dolphin	200	701	3	3	2	14	26
Common dolphin	75	480	5	4	3	20	37
Harbor porpoise	64	451	5	4	3	21	40
California Sea Lion	200	701	3	3	2	14	26
Harbor Seal	65	451	5	4	3	21	40

[1] From Yelverton (1981).

year as a result of exposure to impulses from current operations (Table 4.7-3; details in Appendix B). About 0.00042 of these are in territorial waters.

When a rapidly-moving object strikes the water, the area within which marine mammals could be exposed to impulses strong enough to cause TTS is much larger than the area within which physical injury could occur (Figures 4.7-9, 4.7-10). Sound Exposure Levels (SEL) at which TTS is expected are based on the provisional criteria summarized in Table 4.7.1. As a first approximation, we estimated the source levels and propagation of the noise pulse on the assumption that it behaves like a high-explosive detonation near the water's surface (see Section 4.7.1.2-C).

The number of marine mammals exposed to impulses strong enough to cause TTS was estimated taking account of animals at or near the surface (depths 0 to 33 feet [0 to 10 meters]) and those submerged well below the surface (Table 4.7-6). We assumed that the average depth of a submerged marine mammal is 164 feet (50 meters). We assumed that cetaceans in the Sea Range would be submerged 75 percent of the time. This figure is based on a conservative rounding of combined NMFS aerial survey estimates, which indicated that the average cetacean is submerged 72.2 percent of the time. We further assumed that pinnipeds at sea within the Sea Range would be submerged 55 percent of the time. The pinniped figure is also based on combined NMFS aerial survey estimates, with less weight being given to elephant and harbor seals than to the more common California sea lions and fur seals.

Using this procedure, an estimated 4.03[1] marine mammals (of an average population of 460,000 in the Sea Range) would be exposed to TTS due to missiles or targets hitting the water during an average year (Table 4.7-3; details in Tables B-7A and B-7B in Appendix B). Of these, about 0.063 individuals would be threatened and endangered species. *About fifty percent of the 4.03 marine mammals that are subject to TTS are in non-territorial waters.* Any TTS is most likely to be mild, as the received level of the sound pulse is <10 dB above the TTS threshold within the great majority of the area of potential TTS. Thus, the effect of TTS would be transitory and would not be biologically significant to marine mammals. The probability that any individual marine mammal would experience TTS more than once per year approaches zero.

[1] This value is the estimate of total numbers of animals affected based on summing appropriate decimal values across species. This calculation is described in more detail in Section 4.7.4.4-B.

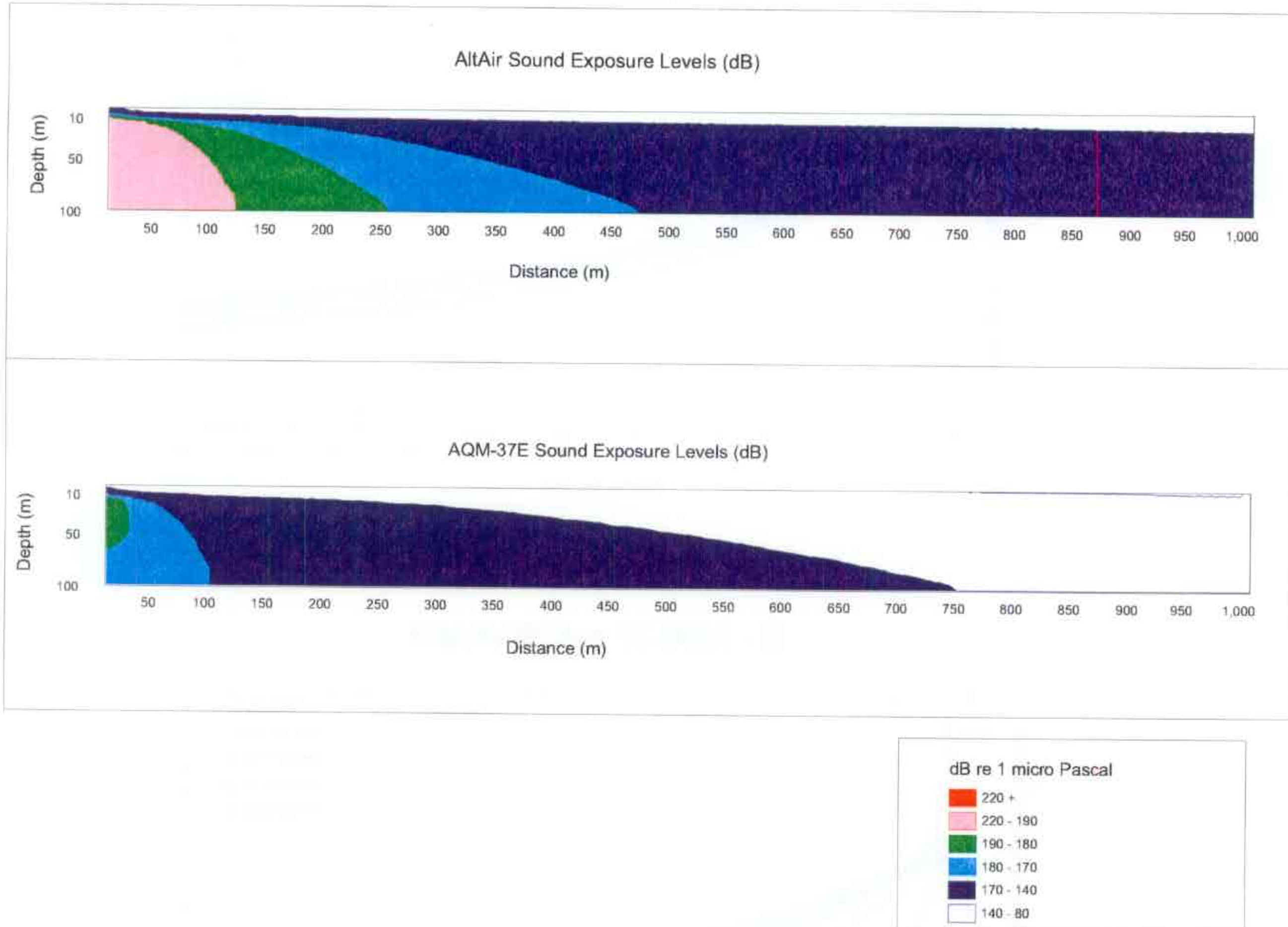
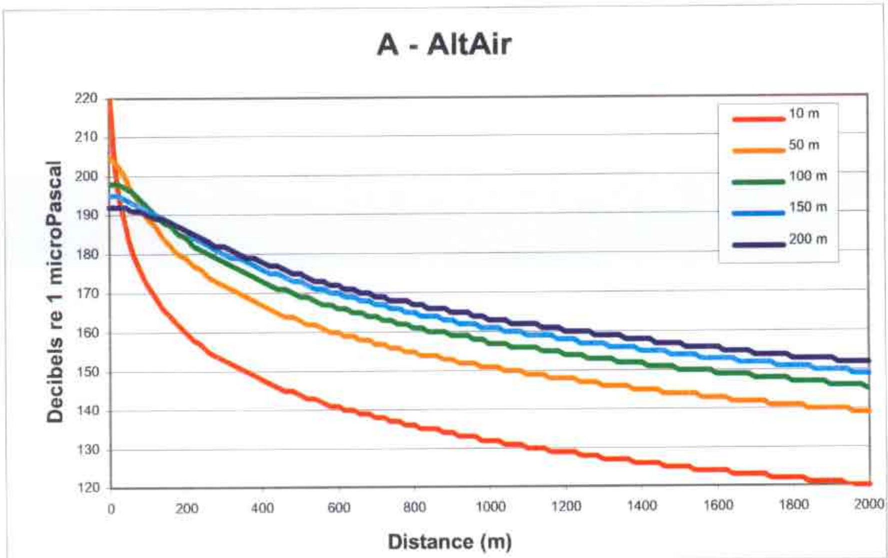


Figure 4.7-9
Sound pressure level contours for intact AQM-37E and AltAir missile hitting the ocean's surface.

It is doubtful that specific mitigation measures are required given the low probability of TTS and the extremely low probability of injury to any marine mammal for any given launch. However, efforts could be made to reduce the risk to marine mammals from surface impacts near locations where mammals concentrate. This will not be possible in cases where the trajectory of the missile or target is unpredictable. However, if the impact location is reasonably predictable, it would be preferable to avoid launches toward locations with marine mammal concentrations. The probable impact zone could be surveyed by aircraft immediately prior to launch. If marine mammals (or more than some defined number of marine mammals) are seen within the impact zone, the launch could then be postponed until a subsequent survey reveals that the marine mammals have left the area of impact.



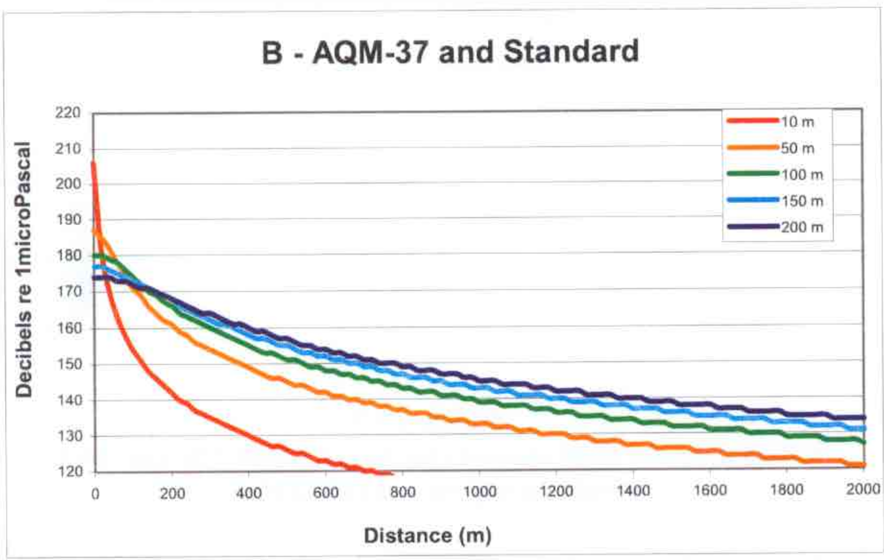
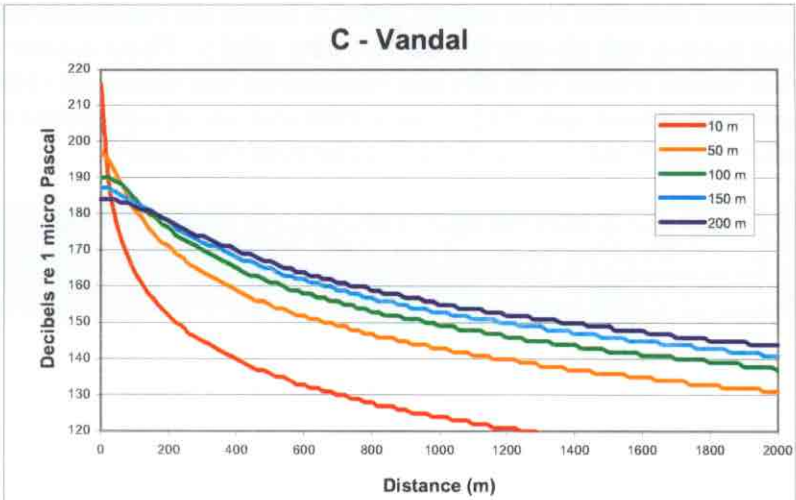
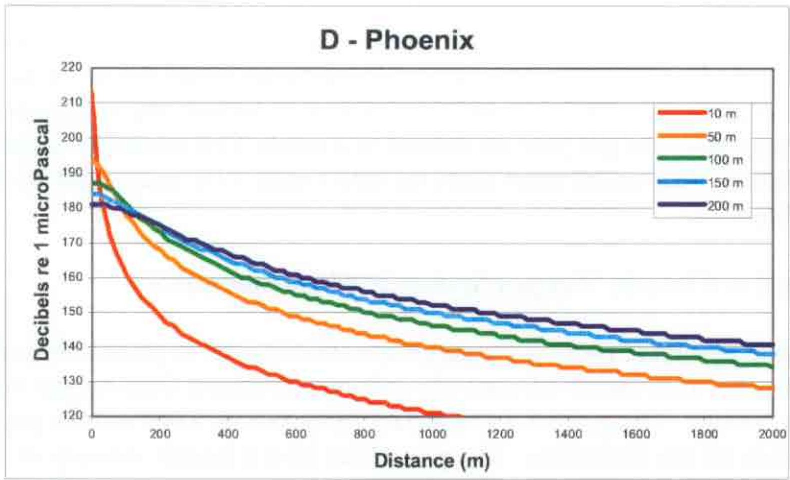


Figure 4.7-10
Sound pressure level contours at five depths for various intact missiles, targets, and mines striking the ocean's surface.





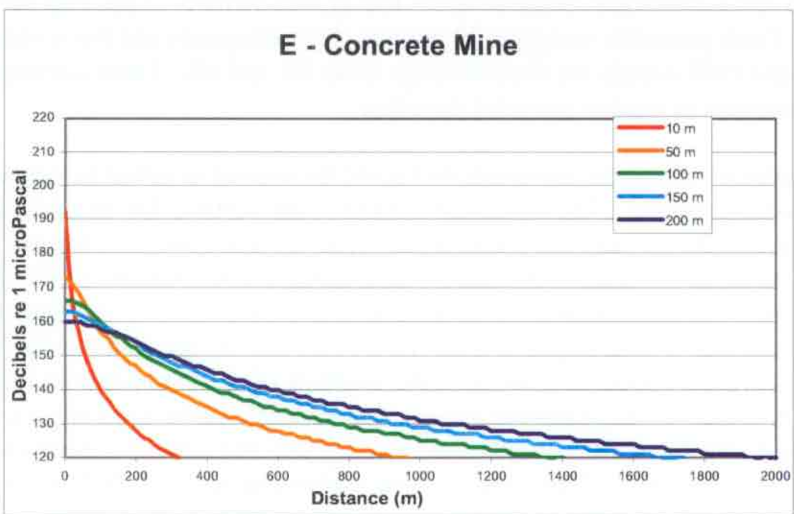


Figure 4.7-10 (continued)
Sound pressure level contours at five depths for various intact missiles, targets, and mines striking the ocean's surface.

Table 4.7-6. Estimated distances from impact point at which the received level of the underwater sound pulse is 180 dB and 190 dB re 1 µPa (SEL). These are the distances within which baleen whales (180 dB) and odontocetes and pinnipeds (190 dB) may experience at least mild TTS. These distances are calculated for animals near the surface (0 to 10 meters depth) and submerged (50 meters).

Impacting Object	Distance to Meet 180 dB re 1 µPa SEL TTS Criterion Level (meters)		Distance to Meet 190 dB re 1 µPa SEL TTS Criterion Level (meters)	
	At Surface	Submerged	At Surface	Submerged
Phoenix	40	120	20	100
Harpoon	10	0	5	0
AQM-37	20	40	10	0
Vandal	40	100	21	60
AltAir	80	180	40	100
Inert Mine	4	-	0	-

In summary, the effects on marine mammals of surface impacts by intact missiles and targets are less than significant. The probability that any intact missile or target would kill or cause physical injury to a marine mammal is small (about 0.001 mammals per year with current Sea Range operations). An estimated 4.03 marine mammals per year are subject to a single TTS incident related to intact missiles or targets hitting the water. This would most likely be only a mild TTS, and would be transitory and not biologically significant.

D - Impacts Related to Close-In Weapon System (CIWS) Operations

The Close-In Weapon System (CIWS) is a weapon system designed to protect ships from anti-ship missiles. CIWS includes a six-barrel 0.8-inch (20-millimeter) caliber Gattling gun adapted from the Air Force M61 Vulcan cannon. The gun has a theoretical firing rate of 3,000 rounds per minute with a very low dispersion pattern for the projectiles. The projectiles have a muzzle velocity of 3,650 feet (1,110 meters) per second and a maximum range of 4,875 feet (1,486 meters). Typically the gun fires a burst of about 200 rounds. Each projectile weighs 0.22 pounds (0.10 kilogram) and has a tungsten penetrator. In the Sea Range, most CIWS rounds are fired in range areas 4A and 4B. These correspond to strata 4 and 5 used in the computation of marine mammal densities.

We estimated the number of marine mammals that could be injured or killed by rounds fired from CIWS systems in the following manner. The maximum area of water surface that might be struck by the rounds fired annually in the Sea Range was estimated as the cross-sectional surface area of a 0.8-inch (20-millimeter) round multiplied by the 3,000 rounds fired during FY95. For each affected stratum, we used the estimates of marine mammal densities that were derived in Section 3.7 (see Figure A-1 in Appendix A). We multiplied the area struck by projectiles in strata 4 and 5 by the average marine mammal densities for strata 4 and 5 to obtain estimates of the numbers of marine mammals likely to be struck by CIWS rounds. Only those marine mammals expected to be at the surface at any given time were considered in this calculation. CIWS rounds fired directly into the water decelerate to non-lethal velocity within 22 inches (56 centimeters) of the water's surface after impact (E. J. Ballow, NAWCWPNS Point Mugu, personal communication, 1998) so the injury risk to cetaceans and pinnipeds swimming underwater would be very low. The procedures used are described in more detail in Appendix B, "Estimates of Numbers of Marine Mammals at Sea that Might Be Injured or Killed."

Based on average annual operations in the Sea Range, an estimated 4.0×10^{-6} marine mammals per year could be hit by rounds from a CIWS system. This is equivalent to one serious injury or death in approximately 285,060 years. About 75 percent of the potentially affected animals would be in territorial waters *and 25 percent in non-territorial waters*. In the highly implausible event that a marine mammal was seriously injured or killed, the impact of CIWS projectiles on its population would be less than significant unless it was a rare and endangered species.

About 1.6×10^{-9} of the marine mammals struck by CIWS projectiles per year per year could be endangered whales in territorial waters, *and* 1.7×10^{-9} *marine mammals struck by projectiles per year could be endangered whales in non-territorial waters*. This is equivalent to one serious injury or death of an endangered whale species in approximately 307,779,583 years.

We also calculated the probability of a marine mammal sustaining injury due to the impulse generated by a CIWS round striking the water nearby. We adopted a conservative approach and assumed that all CIWS rounds hit the water at a velocity equal to the muzzle velocity of 3,650 feet (1,110 meters) per second. Rounds hitting the water at this velocity produce an impulse with a very short rise time—more rapid than that expected from a CIWS round that had traveled on through a ballistic trajectory to an impact location some distance from the gun. We used McLennan's (1997) equation and the spreading loss equation presented in section 4.7.1.2-C to determine the distances from the impact point at which the impulse would diminish to the "1 percent injury/mortality" levels predicted by Yelverton's (1981) equations (Table 4.7-5). (The received sound levels at various distances were computed assuming that the source was a dipole.) The predicted impulse produced by a CIWS round hitting the water would be 3.2 Pascal•seconds at 1 meter (3.3 feet). The predicted impulse is well below the minimum impulse necessary to cause physical injury to a marine mammal. Yelverton's equations predict that a small mammal such as a harbor seal would sustain 1 percent injury/mortality when subjected to an impulse of 450 Pascal•seconds (Table 4.7-5). The applicability of the McLennan (1997) model to small high-speed projectiles is subject to considerable uncertainty. However, quite substantial refinements to the assumptions and equations could be made without substantially altering the conclusion that the impulse would not cause physical injury to marine mammals.

When a rapidly-moving object strikes the water, the radius within which marine mammals are exposed to impulses strong enough to cause TTS is a much larger area than that within which physical injury could occur (Figures 4.7-9, 4.7-10). Sound exposure levels at which TTS is expected are based on the provisional NMFS (1995) criteria summarized in Table 4.7.1. We estimated the source level and propagation of the noise pulse from the impact of a CIWS round on the assumption that it behaves like a high-explosive detonation near the water's surface (see Section 4.7.1.2-C). The estimated sound source level for a CIWS round striking the water's surface would be about 165 dB SEL re 1 μPa at 1 meter (3.3 feet). This is well below the TTS threshold for a single transient event. Marine mammals would not incur TTS from the noise of a CIWS round hitting the water. Even with model refinements, we would not expect source levels to reach the assumed TTS threshold for baleen whales (180 dB SEL re 1 μPa).

We are aware of only one report that describes the source level of a CIWS gun in air, and presents a method of estimating the propagation of sound produced by this weapon system (Hannay et al. 1998). Using the Patter formula in a MathCAD computer model (refer to Section 3.3 of the EIS/OEIS), we estimated the area near the CIWS gun muzzles within which pinnipeds might be exposed to sounds of sufficient intensity to elicit TTS in air (145 dB SEL re 20 μPa). We assumed a worse-case scenario where the gun fires horizontally, its muzzle 15 feet (5 meters) above the water surface, and no ship structure between the gun and the water. In this case, the water surface exposed to 145 dB SEL re 20 μPa would be an approximately rectangular-shaped patch of 4,994 square feet (464 square meters). This

patch would extend out 26 feet (7.9 meters) along the line of the gun and laterally across the line of fire to 14 feet (4.3 meters) on either side. The ship would move approximately 164 feet (50 meters) during the burst. Assuming that the CIWS is fired 15 times per year on the Sea Range in areas 4A and 4B, then about 0.021 pinnipeds could be exposed to TTS. This is a conservative (high) estimate because it assumes that all pinnipeds at the water surface have their ears above water. About 0.016 of these pinnipeds would be in territorial waters *and about 0.005 pinnipeds would be in non-territorial waters*. Sound levels below the water surface would not exceed a value that might cause TTS in baleen whales or other marine mammals.

In summary, the probability of CIWS rounds striking a marine mammal is extremely low. The impulsive energy produced by a CIWS round striking the water is insufficient to cause physical injury or TTS in marine mammals. About 0.021 pinnipeds could be exposed to TTS caused by the sound of the CIWS system being fired. Firing the CIWS has less than significant impacts on marine mammal populations within the Sea Range.

4.7.2.2 Air-to-Air Operations

Each subsection from 4.7.2.2 through 4.7.2.6 briefly mentions the military activities associated with one type of test and training operation on the Sea Range. This subsection addresses air-to-air operations. Each subsection then summarizes the expected impacts of those types of activities on marine mammals, based on the previous literature review and analysis for various categories of military activities. Several of those military activities (including aircraft operations, target launches, debris falling into the ocean, and intact missiles or targets impacting the ocean) recur in various different test and training operations.

Current air-to-air operations involve high-altitude aircraft operations, launch of targets from NAS Point Mugu, target debris falling into the ocean, occasional intact missiles or targets impacting the ocean, and possibly target recovery using a helicopter. As discussed in Section 4.7.2.1, no injuries or deaths, and few temporary alterations of behavior, are expected as a result of these operations. Debris from missile and target flights associated with air-to-air operations was included in the calculations summarized in Section 4.7.2.1-C. Impacts of air-to-air operations on marine mammals are less than significant.

4.7.2.3 Air-to-Surface Operations

Current air-to-surface operations involve the activities mentioned above, as well as ship activities, surface-based targets, and mine drops. The impacts on marine mammals are similar to those described in Section 4.7.2.1. As shown in Section 4.7.2.1, the probability that any of 300 missiles and targets (the approximate annual use for all types of current operations) hits a marine mammal is very low. There is also only a low probability that a marine mammal will be hit and injured or killed during inert mine drops as part of current air-to-surface operations (FLEETEX and otherwise). Impacts of inert mine drops on marine mammals are summarized in Section 4.7.2.7-D, below. Impacts of air-to-surface operations on marine mammals are less than significant.

4.7.2.4 Surface-to-Air Operations

Current surface-to-air operations involve the activities mentioned above in air-to-air operations, the launch of targets from San Nicolas Island or NAS Point Mugu, and the use of ships. The impacts of these activities on marine mammals are discussed in Section 4.7.2.1. Impacts of surface-to-air operations on marine mammals are less than significant.

4.7.2.5 Surface-to-Surface Operations

Current surface-to-surface operations involve a surface-based target and support boat, a ship, ship-launched missiles, and low-level pursuit by a chase aircraft. Impacts of individual activities are discussed in Section 4.7.2.1. The impacts of surface-to-surface operations on marine mammals are less than significant.

4.7.2.6 Subsurface-to-Surface Operations

Current subsurface-to-surface operations involve the activities mentioned above in surface-to-surface operations, as well as the use of a submarine to launch cruise missiles.

Subsurface missile launches are a source of underwater and aerial sound, launch debris (missile shrouds and spent booster motor), and combustion byproducts from booster propellant (Section 4.7.2.1-A). In addition, these subsurface launches are sources of potential falling debris, or may result in intact missiles impacting the surface at the termination of the missile flight as discussed in Section 4.7.2.1-C. Given the low launch rate, there is an extremely low probability that one of these missiles would strike a marine mammal on launch. We estimate that 5×10^{-7} marine mammals per year might be struck assuming a single launch per year in stratum 4. There is also a very low probability that any marine mammal would be struck by launch debris or propellants during the ascent through the water to the sea surface. Any residual byproducts of booster propellant combustion will quickly dilute in seawater (see Section 4.7.1.5-C). The impacts of current subsurface-to-surface operations on marine mammals are less than significant.

4.7.2.7 Ancillary Operations

A - Radar and Microwaves

Safe levels for exposure of humans to non-ionizing electromagnetic radiation are discussed in EIS/OEIS Section 3.14. At San Nicolas Island, the HERP (Hazards of Electromagnetic Radiation to Personnel) zones around the transmitters are confined to areas well within the interior of the island. The HERP zones exclude the beach areas where pinnipeds occur (EIS/OEIS Figure 3.14-4). The same is true at NAS Point Mugu with the exception of very small areas just inside the entrance to Mugu Lagoon and at Laguna Point (EIS/OEIS Figure 3.14-1). Pinnipeds hauled out at NAS Point Mugu and on San Nicolas Island reside below the elevation angles at which radar and other electromagnetic beams normally are directed from the transmitters, and in many cases (especially at San Nicolas Island) are not in the line of sight from the transmitters. Transmission of radar energy is largely limited to line-of-sight. Effects of electromagnetic radiation on marine mammals are less than significant.

B - Chaff and Flares

A review of literature, combined with controlled experiments, revealed that chaff and self-defense flare use pose little risk to the environment or to marine mammals (see Section 4.7.1.5-A). Marine mammals could ingest chaff fibers with water or food, or the baleen of baleen whales could trap small amounts of chaff. Such effects are likely to be short-term and unlikely to cause internal damage. Impacts of chaff on marine mammals are less than significant.

Toxicity is not a concern with self-defense flares since the primary material in flares, magnesium, is not highly toxic (see Section 4.7.1.5-A), and will normally combust before striking the land or sea surface. It

is unlikely that marine mammals would ingest flare material because it would rapidly sink. The probability of a marine mammal being injured by a falling dud flare is extremely remote. Marine mammals, particularly pinnipeds, could become entangled in a parachute attached to a ship-launched illumination flare. A small parachute might resemble a jellyfish that is prey for some species of marine mammals. However, the parachute would remain attached to the flare and sink rapidly. Only about 15 flare operations occur per year. Thus, the possibility of entanglement is very remote and the impact of flares on marine mammals is less than significant.

C - Lasers

Use of laser systems for detection and guidance commonly occurs on the Sea Range, primarily in association with missile testing activities. The eye hazard distance for the types of laser designators and range-finders used on the Sea Range is 12 NM (22.2 kilometers) (EIS/OEIS Section 4.14). The beam is very narrow. Also, these lasers are normally directed at military objects (e.g., missiles in flight above the water surface). Hence, the probability of illuminating a marine mammal is extremely low. Given the low probability of hitting marine mammals with debris (Section 4.7.2.1-C), the probability of contacting a marine mammal, especially their eyes, with a laser beam is very small. Impacts of current laser operations on marine mammals are less than significant.

D - Inert Mine Drops

Under current conditions, about 50 inert mine shapes are dropped per year during FLEETEX operations and other air-to-surface operations. Inert mines are dropped in a controlled way over a small area of the Sea Range near Santa Rosa Island extending from a point offshore of Skunk Point to a point offshore of Carrington Point (Figure 3.0-14 of the EIS/OEIS). The drop area is monitored carefully prior to and following the drop operation. We estimated the "effective" surface area of the inert mines by assuming that it would be equal to the maximum surface area of a concrete mine (10.8 square feet [1 square meter]) multiplied by the number of mines dropped. In FY95, this was 49 mines. We multiplied this "effective" mine area by the average marine mammal density for the relevant stratum to obtain estimates of the numbers of marine mammals likely to be struck by these mines (see Appendix B). The possibility that one or more mines will strike and injure or kill a marine mammal is very low: estimated as 0.00047 marine mammals per year (Table 4.7-3).

The calculated radii around the impact points of inert mines within which TTS might occur are very small–essentially zero for odontocetes and pinnipeds (190 dB re 1 μPa SEL criterion), and about 13 feet (4 meters) for baleen whales (180 dB SEL criterion) (Table 4.7-6). The probability that any marine mammal would experience TTS as a result of an inert mine drop is negligible. The acoustic impacts of inert mines hitting the ocean's surface on marine mammals are less than significant.

Some of the mine shapes are designed for recovery. High-frequency (28-45 kHz) pingers with source levels of 175 dB re 1 μPa at 1 meter (3.3 feet) are attached to about 40 percent of the inert mines. The moderately high frequencies emitted by these pingers are inaudible or at most only faintly audible to baleen whales, but audible to seals, sea lions, and toothed whales. Their source levels are less than the assumed underwater TTS thresholds of pinnipeds and toothed whales (*cf.* Table 4.7-1), so TTS is not expected. High frequency sounds attenuate rapidly in seawater, so any disturbance effects would be localized if they occur at all. Because of the localized and pulsed (although repeated) nature of these sounds, any disturbance effects on pinnipeds or toothed whales are less than significant.

Given the low probability that an inert mine will strike a marine mammal or cause TTS, the impacts of inert mine drops on marine mammals are less than significant.

4.7.2.8 Current Fleet Exercise Training

FLEETEXs include a combination of operations and activities discussed in Sections 4.7.2.1 to 4.7.2.7. Some marine mammals could temporarily change their behavior in response to transient and more prolonged noise emissions during a FLEETEX (approximately 2-3 days per FLEETEX; less at any one location). However, temporary behavioral changes, including temporary localized displacement of some baleen and sperm whales by vessel traffic (Section 4.7.2.1-B), are not expected to have significant biological effects. Impacts of these combined activities on marine mammals are less than significant.

4.7.2.9 Littoral Warfare Training

Littoral warfare training is routinely done in areas not including beaches used by pinnipeds. If this training were done near beaches used by pinnipeds, any impacts on marine mammals from littoral warfare training would be a result of surface craft activities and beach landings. Underwater noise from the boat engines could cause short-term changes in behavior and temporary displacement of some species in the water. Such temporary behavioral changes in the water would result in less than significant impacts.

If landings were to be made on beaches where pinnipeds are hauled out, then the activity would likely cause stampedes of pinnipeds into the water, which would constitute strong disturbance. This could result in the injury, death, or abandonment and subsequent death of some individual pinnipeds, especially of some pups and juveniles. However, under present policy, beach landings are normally limited to locations and seasons when pinnipeds are absent or scarce. With these existing procedures in place, impacts on marine mammals are less than significant.

4.7.2.10 Hazardous Constituents

All of the hazardous constituents released into the environment during Sea Range activities are expected to be widely-scattered in very low concentrations. The water quality analysis indicated that saltwater concentrations of constituents of concern resulting from Sea Range operations are all well below water quality criteria established for the protection of aquatic life (refer to Section 4.4 of the EIS/OEIS and Section 4.7.1.5-C of this report). Impacts of release of hazardous constituents on marine mammals are less than significant.

4.7.2.11 Impact Summary - Current Operations

All of the current operations included in the No Action Alternative have less than significant impacts on marine mammal populations. It is possible that small numbers of individual marine mammals, mainly of the most common species, are subject to TTS from noise associated with surface impacts of missiles or targets, or to injury or death from pinniped stampedes on beaches, or (rarely) from falling debris or missiles. These effects have not been documented on the range, and do not lead to significant effects on marine mammal populations.

4.7.3 Minimum Requirement Alternative

This alternative would include current operations (as discussed above) plus nearshore intercept events close to San Nicolas Island, an increase from two to three FLEETEXs per year, and facility modernization at San Nicolas Island. Therefore, the impacts of this alternative would include those previously discussed plus the following additional impacts.

4.7.3.1 Theater Missile Defense Element - Nearshore Intercept

This type of event would include a target intercept at 50 to 1,000 feet (15-305 meters) altitude and at least 1 NM (1.9 kilometers) offshore of the northwest or southeast end of San Nicolas Island. There would be a subsonic flight of a target parallel to the southern coast of San Nicolas Island 0.5-1 NM (0.9-1.9 kilometers) off the shoreline and at or below 1,000 feet (305 meters) altitude. A supersonic missile (e.g., Standard) en route to the intercept would fly past the western or eastern end of the island, possibly as close as 1 NM (1.9 kilometers) away.

Pinnipeds seem quite tolerant of sonic booms, although their responses to the booms vary according to the season and age structure of the hauled-out group (Section 4.7.1.4-A). The sonic boom from a Standard or similar missile is less intense than that from aircraft or the large missiles to which pinnipeds have occasionally been reported to react. Pinnipeds on the beaches at San Nicolas Island may show minor alerting responses to the sight or sound of the target, missile, or intercept, but a stampede from the beach into the water is not expected. Likewise, pinnipeds and sea otters in the water below the flight paths are not expected to show more than minor alerting responses or perhaps a hasty dive. These effects would be less than significant (Section 4.7.1.1).

Marine mammals could be hit by debris from the planned eight nearshore intercept events per year. Debris could land in nearshore areas proposed for this type of test (i.e., 1 NM [1.9 kilometers] or more offshore). The specific density of marine mammals in the nearshore waters around San Nicolas Island at different times of year has not been documented. However, pinniped densities there are undoubtedly higher than in the broader stratum extending out to 12 NM (22.2 kilometers) offshore from San Nicolas Island for which approximate densities have been estimated (see companion report on "Descriptions of Marine Mammal Populations," in this volume). Also, sea otters occur off the western end of San Nicolas Island.

Even if the actual marine mammal density under the nearshore intercept point were five times higher than for the general area within 12 NM (22.2 kilometers) of San Nicolas Island, the probability of a marine mammal being seriously injured or killed by falling debris from eight nearshore intercepts per year would be only about 0.0015 (Table 4.7-7). Detailed calculations are shown in Table B-4 in Appendix B. It is also very unlikely that a marine mammal would be injured or killed by the shock waves from a nearby impact during a nearshore intercept event (0.0001 animals per year). This figure again assumes a marine mammal density five times higher than that calculated for the general area.

The number of animals likely to be exposed to a sound pulse strong enough to cause TTS, probably mild, is also low (3.1 per year; Table 4.7-7).

Impacts of nearshore intercept testing or training events on marine mammals would be less than significant. Although impacts on sea otters (as well as pinnipeds and cetaceans) would be less than significant, any special concern about sea otters could be mitigated by conducting some or all nearshore

Table 4.7-7. Numbers of marine mammals expected to be exposed to injury, mortality, or Temporary Threshold Shift per year as a result of objects striking the water surface under the Minimum Requirement Alternative.[1]

Source of Injury or Mortality	Numbers of Marine Mammals Exposed: Territorial Water	*Non-territorial Waters*	Total
Injury or mortality from missile debris			
Nearshore Intercept	0.0015	*0.0000*	0.0015
Additional FLEETEX	0.0000	*0.0003*	0.0003
Current Operations	0.0007	*0.0014*	0.0021
Total: Minimum Requirement Alternative + Current Operations	0.0022	*0.0016*	0.0038
Injury or mortality from inert mine drops			
Additional FLEETEX	0.0002	*0.0000*	0.0002
Current Operations	0.0005	*0.0000*	0.0005
Total: Minimum Requirement Alternative + Current Operations	0.0006	*0.0000*	0.0006
Injury or mortality due to missile impact or shock waves			
Nearshore Intercept	0.0001	*0.0000*	0.0001
Additional FLEETEX	0.0000	*0.0001*	0.0002
Current Operations	0.0004	0.0009	0.0013
Total: Minimum Requirement Alternative + Current Operations	0.0006	0.0010	0.0016
Exposure to impulses causing Temporary Threshold Shift[2]			
Nearshore Intercept	3.1078	*0.0000*	3.1078
Additional FLEETEX	0.0949	*0.2208*	0.3157
Current Operations (Includes CIWS gun noise[3])	1.9563	*2.0983*	4.0545
Total: Minimum Requirement Alternative + Current Operations	5.1589	*2.3191*	7.4780

[1] Numbers included in the text have been rounded for readability.
[2] Noise produced by low flying Vandal targets does not cause TTS.
[3] CIWS gun noise applies only to seals with their heads above water.

intercept events off the southeast rather than the west end of San Nicolas Island. Sea otters do not occur off the southeast end (see Section 3.7.4.4).

4.7.3.2 Training Element - Fleet Exercise Training

A FLEETEX includes a combination of operations and activities discussed in Sections 4.7.2.1 to 4.7.2.8 under the No Action Alternative. Debris and shock waves from missiles and targets associated with an additional FLEETEX (i.e., three rather than two per year) are expected to kill or injure an additional 0.0005 marine mammal beyond the estimated 0.003 injured or killed during all current operations (Table 4.7-7). Detailed calculations are shown in Table B-3 in Appendix B. *Any additional injuries or deaths would most likely occur in non-territorial waters.* Also, during an additional FLEETEX, an additional 0.0002 marine mammals are predicted to be injured or killed during inert mine drops, based on the same assumptions given in Section 4.7.2.7-D (Table 4.7-7). An additional 0.32 marine mammals per year might be subject to mild TTS due to exposure to strong sound pulses from missiles or targets striking the water (Table 4.7-7).

Some marine mammals (especially baleen or sperm whales) could temporarily change their behavior or show temporary avoidance in response to noise produced during a FLEETEX (approximately 2-3 days

per FLEETEX; less than that at any one location). However, these temporary behavioral changes and avoidance are not expected to be biologically significant.

Overall, impacts of an additional FLEETEX (i.e., three rather than two exercises per year) on marine mammals would be less than significant.

4.7.3.3 Facility Modernization Element - Multiple-Purpose Instrumentation Sites

Construction of five multiple-purpose instrumentation sites on San Nicolas Island would occur at distances greater than 0.5 mile (0.8 kilometer) from any marine mammal haul-out area, and thus would not interfere with seals hauled out on these beaches. Pinnipeds may be exposed to construction noise, or the visual stimuli of builders, construction equipment, and the transport of building materials. These activities would take place inland from the haul-out site. As a result, disturbances to pinnipeds on the beach would be less than if the source of disturbance originated either closer, or from the direction of the sea (and their escape route). Impacts on marine mammals from construction would be less than significant.

New instrumentation may include operation of electronic devices transmitting microwave signals. As discussed in Section 4.7.2.7-A, pinnipeds that haul out on San Nicolas Island would not be exposed to significant electromagnetic radiation as a result of the construction of these new instrumentation facilities.

Thus, the impacts on marine mammals from construction and operation of the proposed multiple-purpose instrumentation sites would be less than significant.

4.7.3.4 Impact Summary - Minimum Requirement Alternative

Impacts on marine mammal populations from all operations included in the Minimum Requirement Alternative, including current operations plus the additional components described above, would be less than significant. About 7.5 individual marine mammals per year, mainly of the most common species, would be subject to mild TTS from noise associated with missiles and targets striking the surface of the ocean, as compared with 4.1 during current operations (Table 4.7-7). Under the Minimum Requirement Alternative, approximately 0.005 marine mammals per year would be injured or killed by falling debris or shock waves generated by intact missiles hitting the water, as compared with 0.003 during current operations. An unknown number of seal pups may be subject to injury or death from pinniped stampedes on beaches, as during current operations. It has not been verified that any such injuries or deaths occur. In any case, if they occur, these injuries or deaths would have less than significant effects on the pinniped populations. Impacts of the Minimum Requirement Alternative on marine mammal populations would be less than significant.

4.7.4 Preferred Alternative

This alternative would include current operations (as discussed in Section 4.7.2), the three additional elements described above under "Minimum Requirement Alternative," and several more elements: Theater Missile Defense testing and training events, special warfare training, and facility modernization at NAS Point Mugu and San Nicolas Island. Therefore, the impacts of the Preferred Alternative would include those previously discussed plus the following additional impacts.

4.7.4.1 Theater Missile Defense Element

Theater Missile Defense events on the Sea Range could include boost phase intercept, upper tier, and lower tier testing and training operations. Three of each of these types of Theater Missile Defense events are proposed per year. It is not known whether any pinnipeds would stampede into the water during launches from San Nicolas Island (see Section 4.7.4.3-B). At sea, these nine events would expose an estimated additional 0.0008 marine mammals per year to injury or mortality from debris, direct contact, or shock waves (Table 4.7-8). The calculations are described in detail in Table B-5 in Appendix B. An additional 0.61 marine mammals per year would be exposed to TTS, probably mild (Table 4.7-8).

Nearshore intercept events would also be part of the Theater Missile Defense Element. The characteristics and impacts of nearshore intercept events planned under the Preferred Alternative would be the same as those previously described under the Minimum Requirement Alternative.

A - Boost Phase Intercept

There could be a maximum of three boost phase intercept (BPI) tests or training events per year if the Preferred Alternative were implemented. BPI events could include the launch of a Lance or other missile weighing up to 50,000 pounds (or 22,700 kilograms, about 1.5 times the weight of a Vandal) from the west-central part of San Nicolas Island. However, the effects of the missile's launch noise on pinnipeds are assumed to be no greater than those of the Vandal (discussed in Section 4.7.2.1) because the launch profile would be more vertical than that of a Vandal, and the missile would be higher when crossing the beach. Assuming that effects of a BPI launch on the pinnipeds at San Nicolas Island would be no greater than those of a Vandal launch, implementation of the Preferred Alternative would result in a total of about eleven Vandal and BPI launches per year as compared with about eight Vandal launches per year now.

As noted in Section 4.7.2.1-A, it is not known whether some individual pinnipeds stampede into the water in response to Vandal launches. If so, and if the same would apply to BPI launches, there would be some risk of injury or mortality of pups, primarily on the western third of San Nicolas Island. There has been a rapid growth in resident pinniped populations despite Vandal and other current operations (see Section 3.7.4.3). Impacts of BPI launches on pinniped populations on San Nicolas Island would be less than significant whether or not there would be any adverse effects on individual pinnipeds.

There is a very low probability that a marine mammal would be killed by falling intact missiles or targets or debris used during three BPI events. The "Theater Missile Defense Element" lines in Table 4.7-8 show the estimated numbers for all three types of Theater Missile Defense events combined (3 BPI events, 3 upper tier events, and 3 lower tier events). Impacts of boost phase intercept testing and training on marine mammals would be less than significant.

B - Upper Tier

Upper tier testing and training events could include the firing of a target missile from San Nicolas Island. About three launches per year are expected. Effects would be similar to those for three boost phase intercept events per year as described above (Section 4.7.4.1-A).

Interceptor missiles could also be fired from a vessel in the Sea Range. Underwater noise from this launch would be very brief and would not significantly affect marine mammals.

Table 4.7-8. Numbers of marine mammals expected to be exposed to injury, mortality, or Temporary Threshold Shift per year as a result of objects striking the water surface under the Preferred Alternative.[1]

Source of Injury or Mortality	Numbers of Marine Mammals Exposed		
	Territorial Water	*Non-territorial Waters*	Total
Injury or mortality from missile debris			
Theater Missile Defense Element	0.0000	*0.0002*	0.0002
Nearshore Intercept	0.0015	*0.0000*	0.0015
Additional FLEETEX	0.0000	*0.0003*	0.0003
Current Operations (Includes CIWS rounds)	0.0007	*0.0014*	0.0021
Total: Preferred Alternative + Current Operations	0.0022	*0.0019*	0.0041
Injury or mortality from inert mine drops			
Additional FLEETEX	0.0002	*0.0000*	0.0002
Current Operations	0.0005	*0.0000*	0.0005
Total: Preferred Alternative + Current Operations	0.0006	*0.0000*	0.0006
Injury or mortality due to missile impact or shock waves			
Theater Missile Defense Element	0.0000	*0.0006*	0.0006
Nearshore Intercept	0.0001	*0.0000*	0.0001
Additional FLEETEX	0.0000	*0.0001*	0.0002
Current Operations	0.0004	*0.0009*	0.0013
Total: Preferred Alternative + Current Operations	0.0006	*0.0016*	0.0022
Exposure to impulses causing Temporary Threshold Shift[2]			
Theater Missile Defense Element	0.0576	*0.5540*	0.6116
Nearshore Intercept	3.1078	*0.0000*	3.1078
Additional FLEETEX	0.0949	*0.2208*	0.3157
Current Operations (Includes CIWS gun noise[3])	1.9563	*2.0983*	4.0545
Total: Preferred Alternative + Current Operations	5.2165	*2.8731*	8.0896

[1] Numbers included in the text have been rounded for readability.
[2] Noise produced by low flying Vandal targets does not cause TTS.
[3] CIWS gun noise applies only to seals with their heads above water.

There is a very low probability that a marine mammal would be killed by falling intact missiles or targets or debris produced by three very high altitude intercepts per year, or the striking of a non-intercepted target missile with the surface of the water. The "Theater Missile Defense Element" lines of Table 4.7-8 include all three types of Theater Missile Defense events that are planned. Impacts of upper tier testing and training events on marine mammals would be less than significant.

C - Lower Tier

Targets and missiles could be launched from San Nicolas Island during lower tier testing and training events. Assuming that launch noise levels would be about the same as those of the Vandal, acoustic impacts on pinnipeds at San Nicolas Island may be less than those of the Vandal because the launch profile would be more vertical than that of a Vandal.

Interceptor missiles could also be fired from a vessel on the Sea Range. Underwater noise from this launch would be very brief and would not affect marine mammals.

There is a very low probability that a marine mammal would be killed by falling intact missiles or targets or debris used during very high altitude intercepts or the impact of a non-intercepted target. The "Theater Missile Defense Element" lines of Table 4.7-8 include all three types of Theater Missile Defense events that are planned. Impacts of lower tier testing and training on marine mammals would be less than significant.

D - Nearshore Intercept

Nearshore intercept events under the Preferred Alternative would have the same characteristics and potential impacts as those described under the Minimum Requirement Alternative (Section 4.7.3.1). There is a very low probability of injury or mortality of a marine mammal during nearshore intercept operations (Table 4.7-8; detailed calculations in Table B-4 of Appendix B). Impacts of nearshore intercept testing and training events on marine mammals would be less than significant. Any residual concern about sea otters could be mitigated by conducting some or all nearshore intercept events off the southeast rather than the west end of San Nicolas Island.

4.7.4.2 Training Element - Fleet Exercise and Special Warfare Training

A - Fleet Exercises

Potential effects of FLEETEXs on marine mammals could result from missile and target debris and termination of missiles within the Sea Range. These impacts have been evaluated in Sections 4.7.2.1 to 4.7.2.8, Section 4.7.3.2, and Table 4.7-8. An additional FLEETEX would expose an estimated 0.0005 marine mammals to injury or mortality from debris and intact missile impacts per year, and 0.32 marine mammals to TTS (Table 4.7-8). Impacts would be less than significant.

Some marine mammals (especially baleen or sperm whales) could temporarily change their behavior or show temporary avoidance in response to noise produced during a FLEETEX (approximately 2-3 days per FLEETEX; less than that at any one location). However, these temporary behavioral changes and avoidance are not expected to be biologically significant.

Impacts of an additional FLEETEX (i.e., three rather than two per year) on marine mammals would be less than significant.

B - Special Warfare

Impacts on marine mammals from special warfare training were evaluated in Section 4.7.2.9. Without mitigation (seasonal and/or location restrictions), this could have adverse impacts on pinnipeds hauled out on the beaches. However, under present policy, beach landings are normally limited to locations and seasons when pinnipeds are absent or scarce. With these existing procedures in place, impacts on marine mammals from two additional special warfare training exercises per year would be less than significant.

4.7.4.3 Facility Modernization Element - NAS Point Mugu and San Nicolas Island

A - Point Mugu Modernization

Under the Preferred Alternative, approximately 6 missiles per year may be launched from the existing Bravo or Charlie pads near the beach at NAS Point Mugu. Their distance from the haul-out area for harbor seals in Mugu Lagoon is sufficient to ensure that received sound levels would be below those

predicted to cause disturbance. Any behavioral responses to launch noise would be limited to the short term and would be less than significant. Some of the missile launches could include the use of solid propellant boosters. The boosters would be ejected and fall into the ocean approximately 0.25 to 0.50 mile (0.40 to 0.80 kilometer) offshore. Most of the propellant in boosters is expended during the launch; unspent fuel would be very limited in quantity and there would be no significant impacts on water quality (refer to Section 4.4 of the EIS/OEIS). Given the extremely low probability of falling debris from other Sea Range operations injuring or killing a marine mammal (see Table 4.7-8), the probability that a booster would strike a marine mammal in the waters off Point Mugu would be very low. Impacts of proposed facility modernization at NAS Point Mugu on marine mammals would be less than significant.

B - San Nicolas Island Modernization

The proposed 50K launch site on San Nicolas Island would be located in the interior of the western portion of the island, near the present Vandal launch pad. It would be used to launch medium-sized missiles weighing up to 50,000 pounds (22,700 kilograms), including those that would be used as targets during Theater Missile Defense events. As discussed in Section 4.7.2.1, there are no data on responses of marine mammals to launch sounds of the types of missiles proposed here at the distances proposed. As in the case of Vandal launches, there is some possibility of stampedes and injury or death of a few individual pinnipeds. However, rocket launches do not appear to have had long-term effects on marine mammal populations on this island, given the increasing populations of elephant seals and California sea lions, and the stable population of harbor seals (Section 3.7.4.3). Although launches of 50K missiles may cause disturbance to some individual pinnipeds, no biologically-significant impacts on marine mammal populations are expected.

Impacts of proposed construction at San Nicolas Island would occur on land and would not affect marine mammals on haul-out beaches.

Impacts of proposed facility modernization at San Nicolas Island on marine mammals would be less than significant.

4.7.4.4 Impact Summary - Preferred Alternative

A - Impacts

Impacts on marine mammal populations from all operations included in the Preferred Alternative, including current operations plus the additional components described above, would be less than significant. As for current operations alone, it is possible that small numbers of individual marine mammals, mainly of the most common species, might be subject to TTS from noise associated with surface impacts of missiles or targets, or to injury or death from pinniped stampedes on beaches. Approximately 0.006 marine mammals per year would be exposed to injury or mortality by falling debris or missiles striking the water under the Preferred Alternative; this would be 0.003 more than during current operations (Tables 4.7-8 and 4.7-9). Effects on marine mammal populations would be less than significant.

B - Calculation of Numbers of Marine Mammals Subject to Injury, Mortality, or Temporary Threshold Shift

For each alternative (No Action, Minimum Requirement, and Preferred), the numbers of marine mammals that would be subject to injury or mortality as a result of direct hits by missile debris and

Table 4.7-9. Summary of numbers of all marine mammals and endangered species expected to be exposed to injury, mortality, or Temporary Threshold Shift per year as a result of objects striking the water surface under all alternatives.[1]

Source Of Injury or Mortality	Numbers of Marine Mammals Exposed			Numbers of Endangered Species Exposed		
	Territorial Waters	*Non-territorial Waters*	Total	Territorial Waters	*Non-territorial Waters*	Total
Intact Missile Hitting the Water						
Mortality Due to Blast-like effects						
Total for Current Operations	0.000418	*0.000851*	0.001268	0.0000044	*0.0001345*	0.0001389
Total for Minimum Requirement Alternative[2]	0.000587	*0.000982*	0.001568	0.0000160	*0.0001612*	0.0001773
Nearshore Intercept	0.000143	*0.000000*	0.000143	0.0000112	*0.0000000*	0.0000112
Additional FLEETEX	0.000026	*0.000131*	0.000157	0.0000004	*0.0000267*	0.0000272
Total for Preferred Alternative[3]	0.000627	*0.001579*	0.002205	0.0000165	*0.0002444*	0.0002609
Theater Missile Defense	0.000040	*0.000597*	0.000637	0.0000004	*0.0000832*	0.0000836
Nearshore Intercept	0.000143	*0.000000*	0.000143	0.0000112	*0.0000000*	0.0000112
Additional FLEETEX	0.000026	*0.000131*	0.000157	0.0000004	*0.0000267*	0.0000272
Temporary Threshold Shift[4]						
Total for Current Operations[5]	1.956251	*2.098280*	4.054531	0.0028550	*0.0601453*	0.0630003
Total for Minimum Requirement Alternative[2]	5.158919	*2.319088*	7.478007	0.0053812	*0.0667118*	0.0720930
Nearshore Intercept	3.107815	*0.000000*	3.107815	0.0023718	*0.0000000*	0.0023718
Additional FLEETEX	0.094852	*0.220808*	0.315661	0.0001544	*0.0065665*	0.0067209
Total for Preferred Alternative[3]	5.216521	*2.873080*	8.089601	0.0054981	*0.0783482*	0.0838463
Theater Missile Defense	0.057603	*0.553992*	0.611594	0.0001169	*0.0116364*	0.0117533
Nearshore Intercept	3.107815	*0.000000*	3.107815	0.0023718	*0.0000000*	0.0023718
Additional FLEETEX	0.094852	*0.220808*	0.315661	0.0001544	*0.0065665*	0.0067209
Debris from Missile or Target						
Total for Current Operations[6]	0.000689	*0.001384*	0.002074	0.0000004	*0.0000099*	0.0000104
Total for Minimum Requirement Alternative[2]	0.002201	*0.001635*	0.003836	0.0000014	*0.0000120*	0.0000134
Nearshore Intercept	0.001470	*0.000000*	0.001470	0.0000009	*0.0000000*	0.0000009
Additional FLEETEX	0.000042	*0.000251*	0.000293	0.0000000	*0.0000021*	0.0000021
Total for Preferred Alternative[3]	0.002217	*0.001863*	0.004081	0.0000014	*0.0000131*	0.0000145
Theater Missile Defense	0.000017	*0.000228*	0.000245	0.0000000	*0.0000011*	0.0000011
Nearshore Intercept	0.001470	*0.000000*	0.001470	0.0000009	*0.0000000*	0.0000009
Additional FLEETEX	0.000042	*0.000251*	0.000293	0.0000000	*0.0000021*	0.0000021
Injury or Mortality from Inert Mine Drops						
Total for Current Operations	0.000471	*0.000000*	0.000471	0.0000083	*0.000000*	0.0000083
Total for Minimum Requirement Alternative[2]	0.000644	*0.000000*	0.000644	0.0000113	*0.000000*	0.0000113
Additional FLEETEX	0.000173	*0.000000*	0.000173	0.0000030	*0.000000*	0.0000030
Total for Preferred Alternative[3]	0.000644	*0.000000*	0.000644	0.0000113	*0.000000*	0.0000113
Additional FLEETEX	0.000173	*0.000000*	0.000173	0.0000030	*0.000000*	0.0000030

1 Numbers included in the text have been rounded for readability.
2 Includes Current Operations, Nearshore Intercept, and additional FLEETEX.
3 Includes Current Operations, Theater Missile Defense, Nearshore Intercept, and additional FLEETEX.
4 Noise from low-flying Vandal targets does not cause TTS. CIWS gun noise applies only to seals with their heads above water.
5 Includes CIWS gun noise.
6 Includes CIWS rounds hitting the water.

(separately) as a result of shock waves from impacts of intact missiles and targets striking the water nearby were estimated. The numbers that would be subject to TTS as a result of intact missiles and

targets hitting the water were also calculated. TTS can occur out to a larger radius than direct physical injury by shock waves.

Separate calculations were done for current operations, Theater Missile Defense, additional FLEETEX, and nearshore intercept events. The results from these calculations were combined as appropriate for the three alternatives. The computations for a given type of effect (e.g., TTS) were done as follows:

1. The area of effect for each of the five types of target or missile was computed based on estimates of the numbers of intact missiles and targets expected to hit the water's surface within the Sea Range and the corresponding distances from missiles at which impacts could occur (see Tables 4.7-4, 4.7-5, and 4.7-6).
2. For each species and stratum, the average annual density was multiplied by the area of effect for each of the five categories of target or missile.
3. The resultant numbers of animals exposed per missile or target impact were summed across species for each of the five vehicle types, and then multiplied by the numbers of vehicles landing in that stratum per year. These subtotals for the five vehicle types were then summed for each stratum.
4. The total numbers of animals affected were adjusted depending on whether the effects occurred only at the surface (debris) or at all depths (shock waves and TTS).

The densities of animals at the surface and below the surface were calculated as numbers per square kilometer and are decimal numbers. The area of effect for each missile or target category and species, in square kilometers, is also a decimal number. Missiles were apportioned to strata based on information provided in Chapter 2 and Appendix B of the EIS/OEIS. Some of these numbers were also decimals. The numbers of animals affected, calculated by multiplication of these decimal values and summing across species are necessarily expressed as decimals because, for most species and types of effect, less than one animal per year is or would be exposed to effects. Sufficient decimal places were retained throughout the calculations to avoid biases that would result if intermediate values had been rounded.

Table 4.7-10 shows the estimated numbers of marine mammals of each species that are expected to be subject to TTS on a "per year" basis as a result of impacts of missiles and targets with the surface of the water. These values have been estimated by subdividing the overall estimated number of endangered plus all non-endangered species (e.g., 0.06 and 3.99 for "Current Operations") in proportion to the average annual densities of the various endangered and non-endangered species in the Sea Range. For most individual species, the expected number is less than one. However, these fractional numbers for individual species contribute to the estimated total number of all marine mammals that would be subject to TTS. The reciprocals of these fractional numbers are estimates of the average interval (in years) between successive occurrences of TTS to a member of that species. Also, these fractional numbers can be used to estimate the number of animals of each species expected to be subject to TTS over an interval exceeding one year in duration (assuming no change in tempo of operations).

Table 4.7-11 shows the estimated numbers of each species that are expected to be exposed to shock waves per year resulting from intact missile or target impacts. Table 4.7-12 shows the estimated numbers of marine mammals of each species that are expected to be exposed to missile debris per year.

Table 4.7-10. Numbers of marine mammals expected to be subject to Temporary Threshold Shift per year as a result of intact missiles and targets hitting the water under each alternative.[1]

	Alternative		
Species	**Current Operations**	**Minimum Requirement**	**Preferred**
Endangered Species			
Blue whale	0.012635	0.014458	0.016815
Fin whale	0.007088	0.008111	0.009434
Sei whale	0.000045	0.000051	0.000059
Humpback whale	0.000458	0.000524	0.000610
Sperm whale	0.042774	0.048948	0.056928
Total Endangered Species	**0.063000**	**0.072093**	**0.083846**
Non-Endangered Species			
Gray whale	0.005720	0.010638	0.011502
Minke whale	0.001563	0.002907	0.003143
Beaked Whales	0.024335	0.045260	0.048936
Killer whale	0.003157	0.005872	0.006349
Pilot whale	0.000000	0.000000	0.000000
Risso's dolphin	0.209899	0.390387	0.422095
Northern right whale dolphin	0.391508	0.728156	0.787299
Bottlenose dolphin	0.010980	0.020421	0.022079
White-sided dolphin	0.151364	0.281518	0.304384
Common dolphin	1.696958	3.156134	3.412483
Striped dolphin	0.030996	0.057649	0.062331
Dall's porpoise	0.047199	0.087784	0.094914
Harbor porpoise	0.000000	0.000000	0.000000
California Sea Lion	1.119173	2.067440	2.234032
Northern Fur Seal	0.168145	0.310613	0.335642
Northern Elephant Seal	0.107898	0.199318	0.215379
Harbor Seal	0.022637	0.041817	0.045187
Total Non-Endangered Species	**3.991531**	**7.405914**	**8.005755**
Total All Species	**4.054531**	**7.478007**	**8.089601**

[1] Numbers included in the text have been rounded for readability.

4.7.5 Threatened and Endangered Species

There are six federally listed threatened and endangered species of marine mammals that might be found in the Sea Range (refer to Section 3.7). One of these species, the northern right whale, is very rare and is not expected to be found there. The other five species – blue, fin, humpback, sei, and sperm whale – are found in low to moderate numbers during some seasons (refer to Section 3.7).

None of the activities proposed by NAWCWPNS Point Mugu as part of the Preferred Alternative, including current operations, is likely to result in injury or mortality to a threatened or endangered species. An endangered whale could be killed by falling debris or injured or killed by impulse from an object striking the water nearby at high speed. However, the chance of this happening is very remote: approximately 0.0003 animals per year for all threatened and endangered species of marine mammals.

Table 4.7-11. Numbers of marine mammals per year expected to be exposed to shock waves resulting from intact missiles or targets hitting the water under each alternative.[1]

Species	Alternative: Current Operations	Minimum Requirement	Preferred
Endangered Species			
Blue whale	0.000028	0.000036	0.000052
Fin whale	0.000016	0.000020	0.000029
Sei whale	0.000000	0.000000	0.000000
Humpback whale	0.000001	0.000001	0.000002
Sperm whale	0.000094	0.000120	0.000177
Total Endangered Species	**0.000139**	**0.000177**	**0.000261**
Non-Endangered Species			
Gray whale	0.000002	0.000002	0.000003
Minke whale	0.000000	0.000001	0.000001
Beaked Whales	0.000007	0.000009	0.000012
Killer whale	0.000001	0.000001	0.000002
Pilot whale	0.000000	0.000000	0.000000
Risso's dolphin	0.000060	0.000074	0.000103
Northern right whale dolphin	0.000111	0.000137	0.000192
Bottlenose dolphin	0.000003	0.000004	0.000005
White-sided dolphin	0.000043	0.000053	0.000074
Common dolphin	0.000483	0.000594	0.000831
Striped dolphin	0.000009	0.000011	0.000015
Dall's porpoise	0.000013	0.000017	0.000023
Harbor porpoise	0.000000	0.000000	0.000000
California Sea Lion	0.000314	0.000386	0.000540
Northern Fur Seal	0.000047	0.000058	0.000081
Northern Elephant Seal	0.000030	0.000037	0.000052
Harbor Seal	0.000006	0.000008	0.000011
Total Non-Endangered Species	**0.001130**	**0.001391**	**0.001945**
Total All Species	**0.001268**	**0.001568**	**0.002205**

[1] Numbers included in the text have been rounded for readability.

Based on recent levels of Sea Range activity, threatened and endangered whales are not likely to experience TTS from missiles or targets entering the water near them (0.063 individuals of threatened and endangered species per year, or one every 16 years, Table 4.7-9). The annual estimates are 0.013 blue whales, 0.007 fin whales, 0.043 sperm whales, 0.0005 humpback whales, and 0.00005 sei whales (Table 4.7-10). *Any case of TTS to threatened and endangered species would very likely be in non-territorial waters (probability 0.06 per year).* Any impairment of hearing would be temporary and probably mild, and it is highly unlikely that any animal would be exposed to TTS more than once. TTS would not have significant biological consequences for individual whales. Overall, the impact of intact missiles or targets entering the water is less than significant.

Other Sea Range activities such as low level overflights by supersonic aircraft or targets, helicopters retrieving recoverable targets, and marine traffic can cause short-term interruptions of marine mammal activities. Given that all of these Sea Range activities are transient or highly mobile, none would result in marine mammals being excluded from important habitat (such as a feeding area) for biologically significant periods of time. Thus, the impacts of these activities would also be less than significant.

Table 4.7-12. Numbers of marine mammals per year expected to be exposed to missile debris from missiles or targets hitting the water under each alternative.[1]

Species	Alternative		
	Current Operations	Minimum Requirement	Preferred
Endangered Species			
Blue whale	0.000002	0.000003	0.000003
Fin whale	0.000001	0.000002	0.000002
Sei whale	0.000000	0.000000	0.000000
Humpback whale	0.000000	0.000000	0.000000
Sperm whale	0.000007	0.000009	0.000010
Total Endangered Species	**0.000010**	**0.000013**	**0.000015**
Non-Endangered Species			
Gray whale	0.000003	0.000006	0.000006
Minke whale	0.000001	0.000002	0.000002
Beaked Whales	0.000013	0.000023	0.000025
Killer whale	0.000002	0.000003	0.000003
Pilot whale	0.000000	0.000000	0.000000
Risso's dolphin	0.000109	0.000202	0.000215
Northern right whale dolphin	0.000203	0.000377	0.000401
Bottlenose dolphin	0.000006	0.000011	0.000011
White-sided dolphin	0.000079	0.000146	0.000155
Common dolphin	0.000882	0.001634	0.001738
Striped dolphin	0.000016	0.000030	0.000032
Dall's porpoise	0.000025	0.000045	0.000048
Harbor porpoise	0.000000	0.000000	0.000000
California Sea Lion	0.000573	0.001062	0.001129
Northern Fur Seal	0.000086	0.000159	0.000170
Northern Elephant Seal	0.000055	0.000102	0.000109
Harbor Seal	0.000012	0.000021	0.000023
Total Non-Endangered Species	**0.002063**	**0.003822**	**0.004066**
Total All Species	**0.002074**	**0.003836**	**0.004081**

[1] Numbers included in the text have been rounded for readability.

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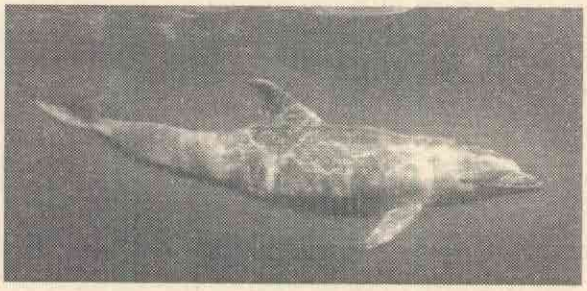
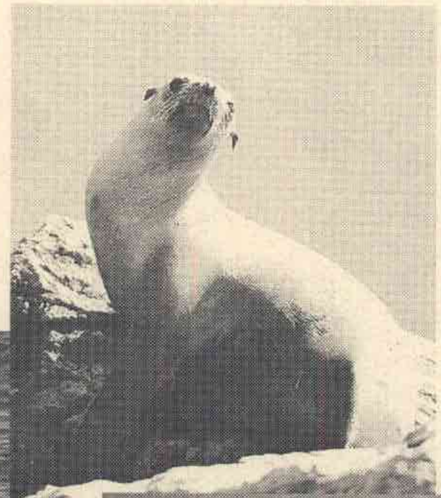
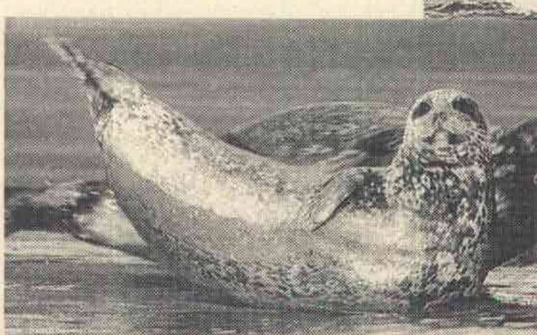
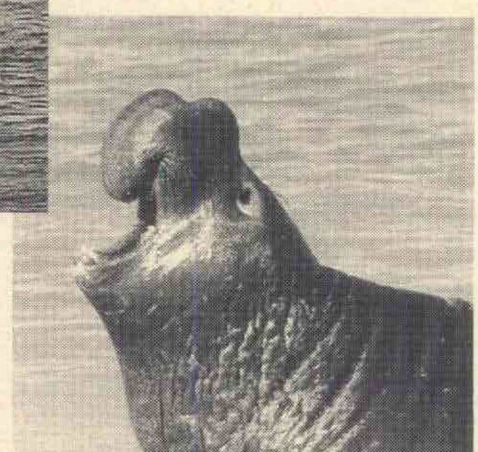


Environmental Consequences References







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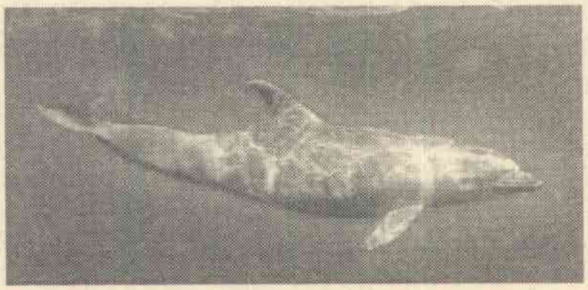

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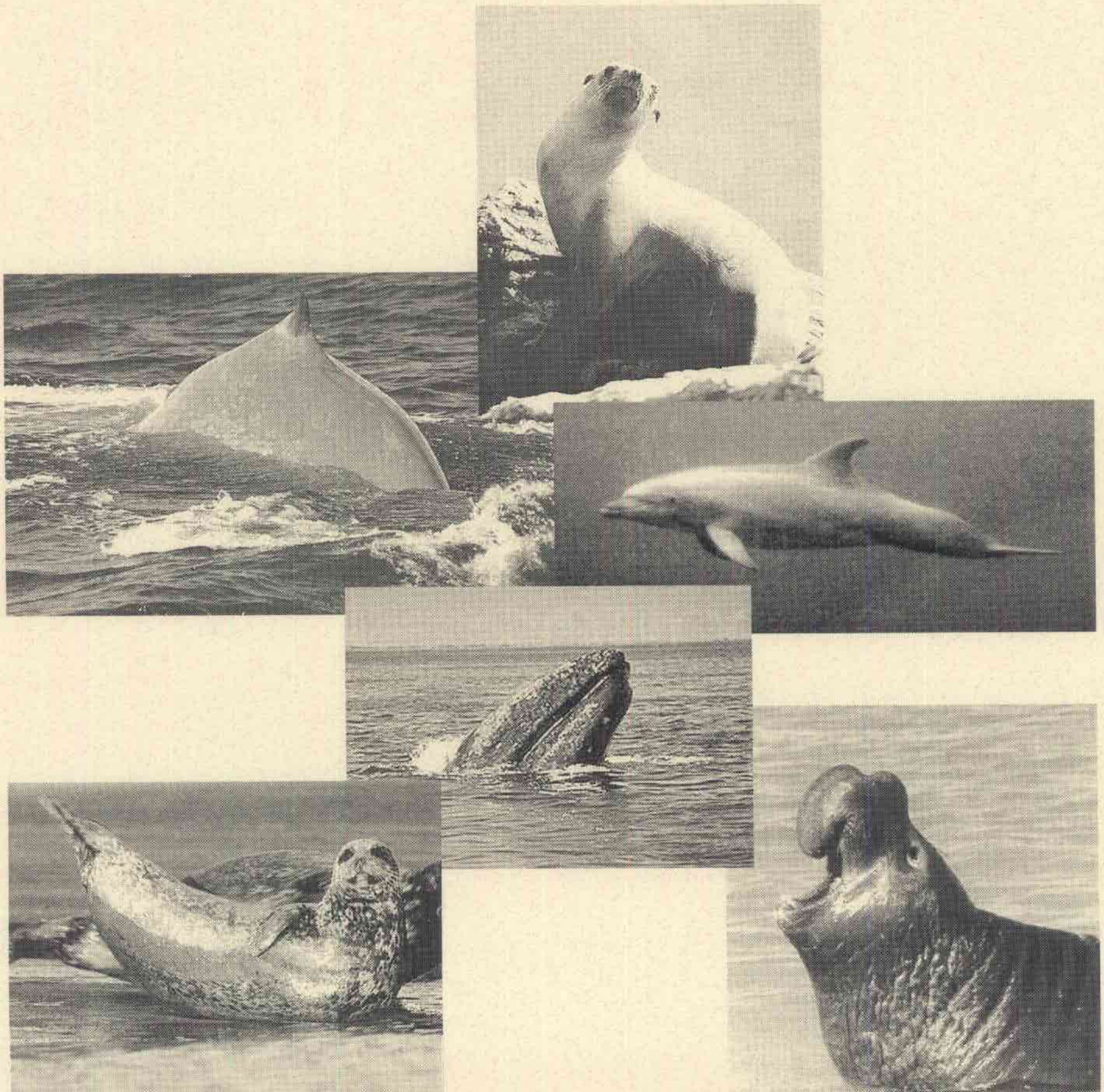

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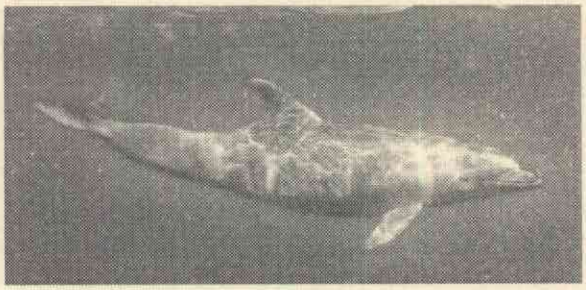
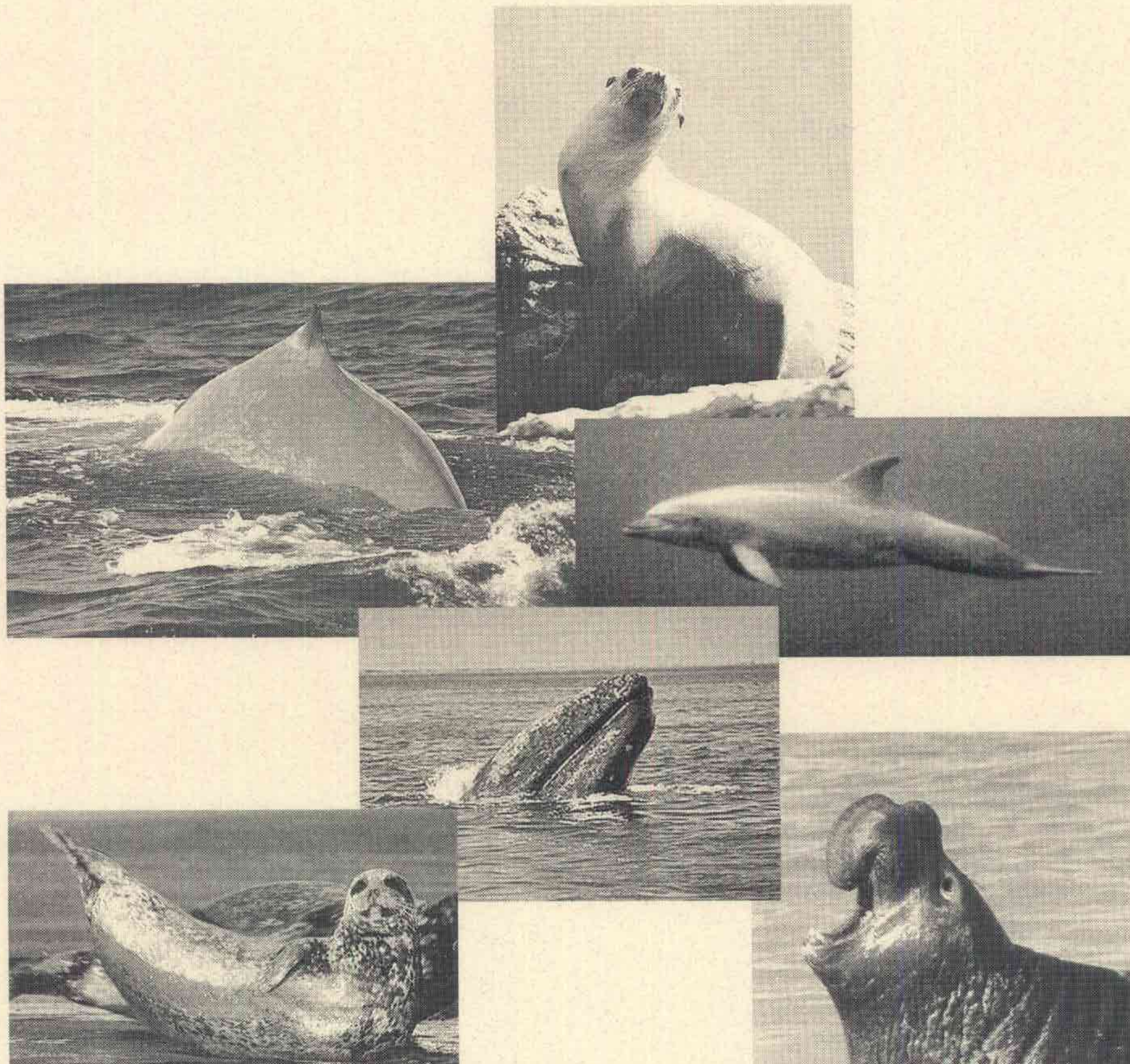


Appendix A



APPENDIX A
ESTIMATING DENSITIES AND NUMBERS OF MARINE MAMMALS AT SEA ON THE POINT MUGU SEA RANGE

Estimates of the densities and numbers of marine mammals of each species in each of the Navy's planning areas in the Point Mugu Sea Range were needed as a basis for predicting potential impacts of Navy activities.

These estimates were computed using the results of systematic aerial and ship surveys conducted during various projects by NMFS/SWFSC and BLM/MMS. The approach to deriving estimates of density and abundance described here was developed by Dr. W. John Richardson, Denis Thomson, and William R. Koski of LGL Limited with input from Dr. Jay Barlow, Dr. Karin Forney, and Jim Carretta of NMFS/SWFSC at La Jolla, CA.

A-1 General Approach

The general approach was to estimate densities of marine mammals within different parts of the study area (strata) during each of four seasons by combining survey effort and sighting data from several different studies. The differing biases of the various surveys were considered in the estimates, as far as possible, so that the data from different studies could be merged.

Available Data

Marine mammal sightings and effort databases were obtained for systematic aerial and ship-based surveys conducted by or for MMS, NMFS, OSPR, and USFWS from 1975 to the present. The databases that were used were studies 1-6 as listed in Table 3.7-3.

Subdivisions of Study Area

The Navy's standard planning areas (used for scheduling purposes) within the Point Mugu Sea Range (Figure 3.7-1) are too small for estimation of densities within each planning area. There was too little aerial or ship survey effort and there were too few marine mammal sightings within individual planning areas. For this reason, the Sea Range was subdivided into nine large strata (Figure A-1A). The criteria for subdividing the Sea Range planning areas into strata were as follows:

- planning area boundaries,
- the 2,000 m depth contour,
- 12 NM from land, and
- for areas shallower than 2,000 m, a line dividing the Sea Range north and south of Point Conception.

South of Point Conception the stratum that included waters <12 NM from land was subdivided into strata 2, 3, 4 and 6 for calculation of pinniped densities because of the presence of haul-out sites in these strata (Figure A-1A). Pinniped densities in nearshore waters are strongly affected by the presence of nearby terrestrial haul-out sites. For cetaceans, strata 2, 3, 4 and 6 were combined into one stratum.

To increase sample sizes for both survey effort and sightings, additional Sea Range areas were created adjacent to the Sea Range offshore from the 2,000 m contour and between the Sea Range and the shore (Figure A-1A). Survey data from the "additional areas" outside of the Sea Range were used to increase sample sizes for estimation of densities of marine mammals within the Sea Range. Strata 8 and 9 were

combined into one stratum which was used to estimate densities in all Sea Range areas beyond the 2,000 m contour.

Seasons

Densities were computed by "oceanographic season" (winter = February to April, spring = May to July, summer = August to October, and autumn = November to January). This was done at the recommendation of NMFS/ SWFSC. These seasonal categories, rather than "calendar quarters", were used to better match changes in distribution and movements of marine mammals with the seasonal changes in oceanographic conditions within and near the Sea Range (Forney 1997). Many of the original data used here, e.g. the BLM/MMS surveys from southern and central California, have been tabulated and described by calendar quarter in the literature. Thus the descriptions of seasonal distribution and abundance in this report may differ from the original presentations of the data.

A-2. Data and Correction Factors

Abundance and relative abundance were estimated by adjusting on-transect, on-effort sightings for

- the reduced probability of detecting an animal with increasing distance from the trackline *f(0)*, and
- detectability (=perception) and availability bias *g(0)*.

We counted only the sightings obtained during sea state conditions that were considered acceptable for the type of survey and the type of marine mammal in question. The "adjusted number of sightings" was multiplied by the average group size for the survey type and season, and the results were tabulated by stratum and season.

Survey effort conducted during sea state conditions that were considered acceptable for that survey type and type of marine mammal was also tabulated for each stratum and season. Sightings and effort from different survey types were weighted differently to take account of the effective survey area of each survey type. Sightings were divided by effort to obtain densities for each season and stratum shown on Figure A-1A. Abundance were then estimated for each Sea Range stratum shown on Figure A-1B.

Sightings

On-effort, on-transect sightings were extracted from the NMFS date set, which was provided by Dr. Jay Barlow, National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. M. Bonnell of Ecological Consulting, Inc., Santa Cruz, CA, provided the BLM/MMS on-effort, on-transect sightings. For the computation of density, only on-effort, on-transect sightings made by primary observers within the allowable sea-state criteria were used. Allowable sea-state conditions for the NMFS/SWFSC data were sea state 4 for most species seen during aerial surveys and sea state 3 for cryptic species. For the ship surveys, allowable sea states were 5 for most species and 2 for cryptic species (Barlow 1995).

All sightings were plotted in the MapInfo GIS program and assigned to one of the large strata. Density and abundance of cetaceans were estimated for five strata (1, 7, 8+9, 5, 2+3+4+6). Estimates of pinniped density and abundance were made for eight strata (1, 2, 3, 4, 5 ,6 ,7, 8+9) (Figure A-3.7.1).

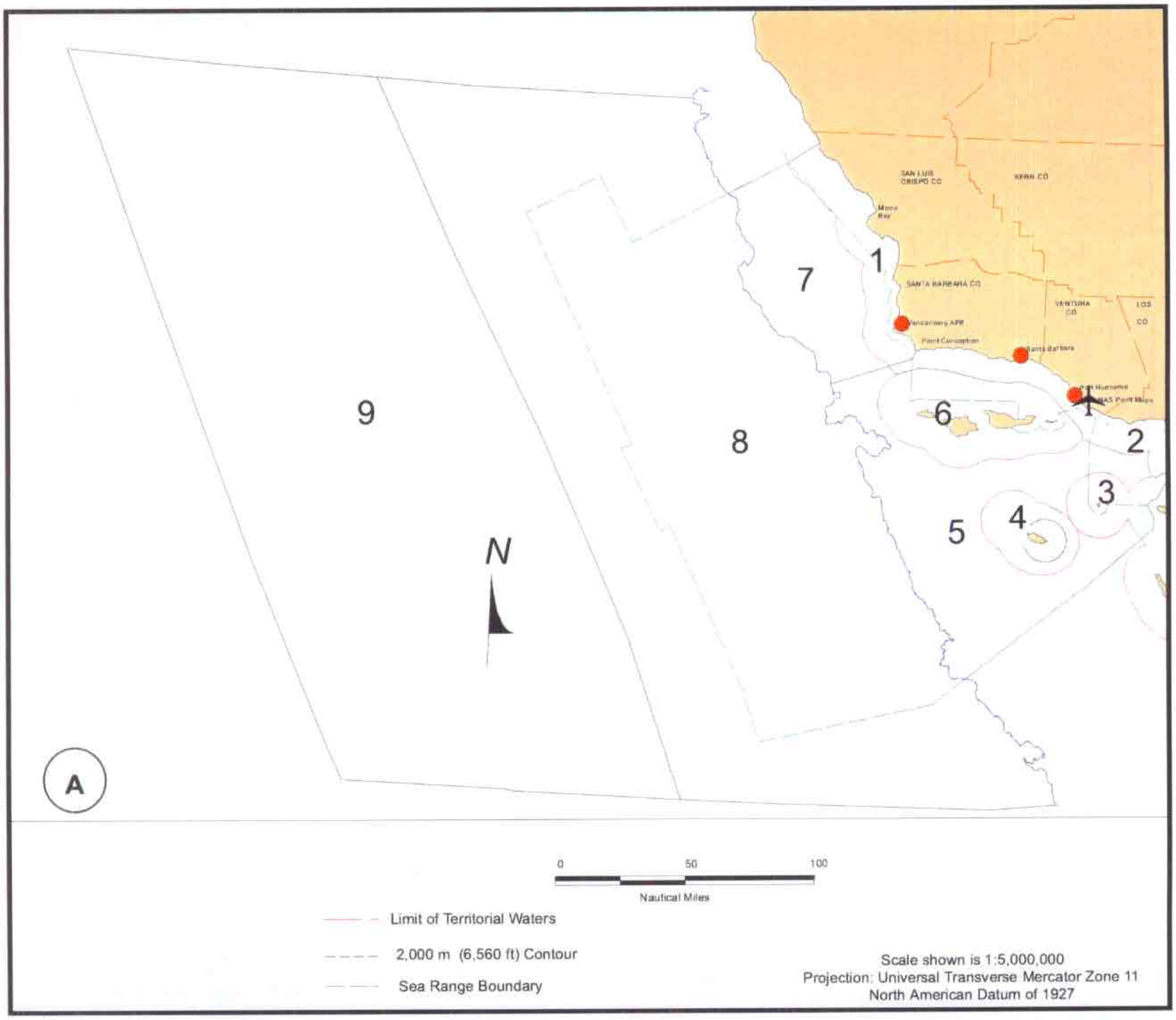


Figure A-1

Strata used to estimate numbers of marine mammals in the Sea Range. *(A)* shows areas that were included when calculating mean densities for each stratum. *(B)* shows the stratum boundaries used when calculating numbers of marine mammals present within the Sea Range in each stratum.

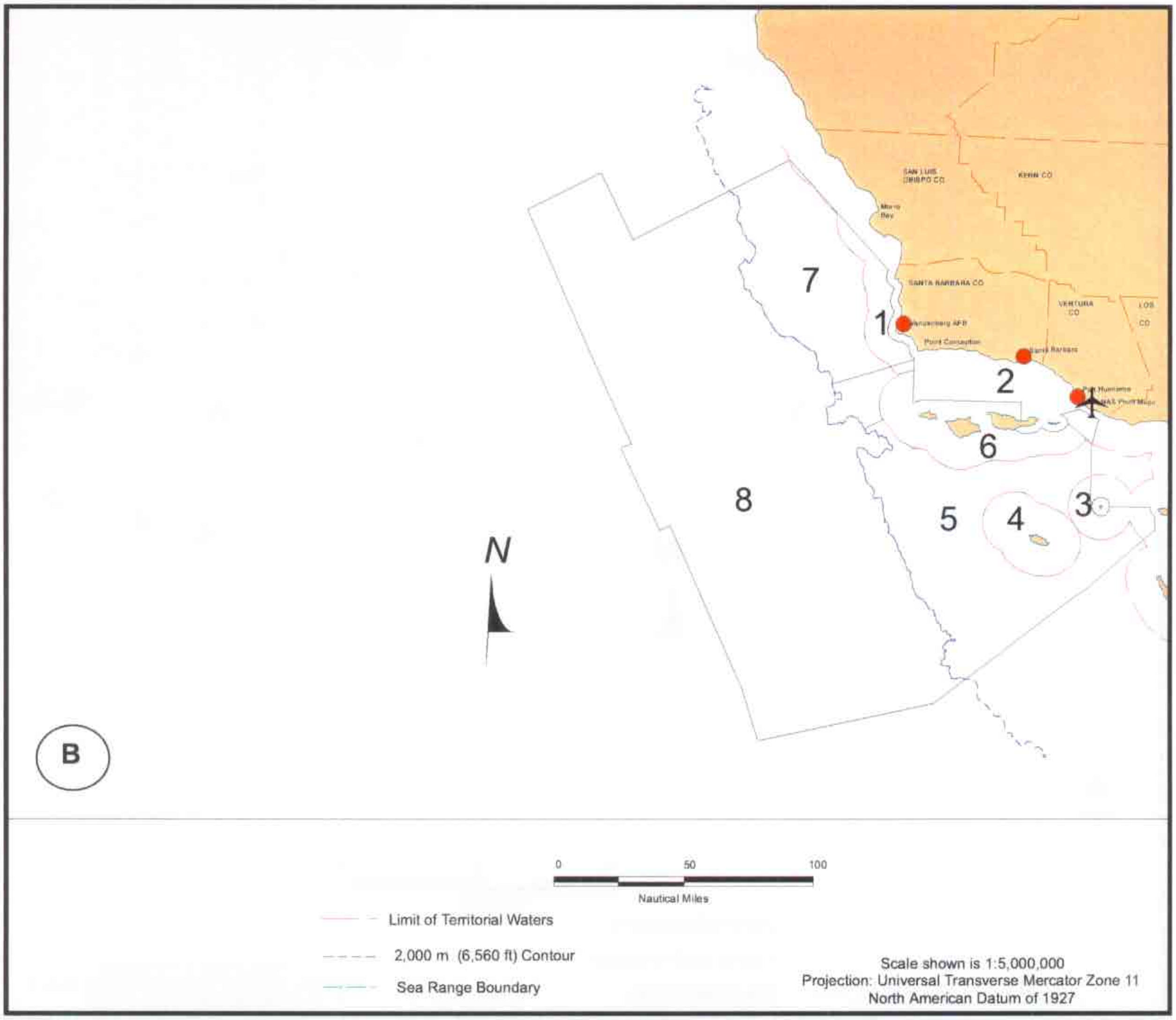


Figure A-1 (continued)
Strata used to estimate numbers of marine mammals in the Sea Range. ***(A)*** **shows areas that were included when calculating mean densities for each stratum.** ***(B)*** **shows the stratum boundaries used when calculating numbers of marine mammals present within the Sea Range in each stratum.**

Some marine mammals are not identified to species during surveys because of distance or poor visibility, or because they dive before observers can identify them. When calculating numbers of each species in an area, exclusion of incompletely identified sightings will result in negatively biased estimates for many species. For the NMFS data, incompletely identified species were assigned a complete identification based on temporal and spatial proximity to completely identified species that most closely matched the incompletely identified species (e.g. small delphinid, baleen whale). This approach was recommended by NMFS/SWFSC.

Line Transect Methodology

During previous analyses of the NMFS sighting data, "Line Transect" methodology was used. In theory, two parameters, $f(0)$ and $g(0)$, can be computed from the raw survey data or from other observations of the species of interest to minimize most of the biases that lead to inaccurate estimates of the actual numbers of mammals present at the time of the survey. $f(0)$ accounts for the reduced probability of detecting an animal as its distance from the trackline increases. $f(0)$ assumes that all animals at some defined location relative to the trackline are seen, or if not seen, are accounted for. $g(0)$ takes account of animals on the trackline that are not detected during the survey. In most cases $g(0)$ takes account of animals that are at the surface and available to be seen but, in fact, are not seen by the primary observer ("detectability bias", otherwise known as "perception bias"). In rare cases, $g(0)$ has been calculated in such a way as to account for the fact that marine mammals are often below the surface as the survey aircraft or vessel passes ("availability bias"). Corrections for availability bias take account of the effects of surfacing and dive behavior on the probability that an animal on the trackline will be at the surface while the surveyors are close enough to have a chance to detect the animal.

To distinguish these two components of $g(0)$, we will refer to

- $g_d(0)$ when we refer to corrections for detectability bias, i.e. for animals at the surface that are missed by the primary observer,
- $g_a(0)$ when we refer to corrections for availability bias, i.e. for mammals not at the surface due to their diving behavior, and
- $g_{a,d}(0)$ when corrections account for both biases.

The failure to account for $g_a(0)$ can cause substantial underestimates of the numbers of marine mammals present in an area, particularly for species that dive for long periods of time and/or when a rapidly-moving survey platform (aircraft) is used. In this analysis, unlike earlier studies, estimates of $g_a(0)$ (availability bias) were included in the estimation of numbers of all species. However, these estimates of $g_a(0)$ are in many cases very preliminary and approximate, as specific studies to estimate $g_a(0)$ have not yet been done for many species and survey types.

We used $g_a(0)$ data from Barlow and Sexton (1996), Laake et al. (1997), Forney and Barlow (1998) and Carretta et al. (1998) for species for which $g_a(0)$ values have been derived. For other species, surfacing and dive data were use to develop approximate $g_a(0)$ factors. In many cases, the only available data on surfacing and dive behavior were obtained from studies conducted outside of southern California. In these cases, the data used were from periods when marine mammal activities would be similar to those of the species while in the Sea Range. For species for which $g_a(0)$ values and surfacing and dive data were not available data, we used $g_a(0)$ values from closely related species.

Group Sizes

Group sizes were estimated for each species, survey type and season. There were too few sightings within the Sea Range to compute group size by season, so group sizes were estimated using all of the on-

effort, on-transect primary sightings for the entire area surveyed. For each survey type, group sizes were estimated by season when the sample size for the season was >8. When the sample size for a season was ≤8, the average sample size for the year was used.

Effort

"On-transect on-effort" effort data were extracted from the NMFS survey data provided by SWFSC. These data were extracted as transect segments of equal sea state. A total of 22,049 linear kilometers of aerial surveys were flown within the area shown in Figure A-1A during the 1991 to 1994 NMFS aerial surveys (red lines in Figure A-2A). A total of 6,030 linear kilometers of shipboard surveys were conducted by NMFS within that area during their 1991 and 1993 shipboard surveys (blue lines within Figure A-2A).

M. Bonnell extracted the effort data for the BLM/MMS data set and provided these as on-effort transect segments or as numbers of kilometers of on-effort transect effort within each 5' x 5' block within the study area. The effort in each of these small blocks was treated as one transect segment. Within the area shown in Figure A-1A , a total of 83,669 linear kilometers of effort were flown for BLM/MMS during high altitude surveys, plus an additional 51,298 km during low altitude surveys (Figure A-2B).

Effort for each survey type was plotted in MapInfo GIS. Transect lines were split when they crossed stratum boundaries. Each of the resulting transect segments was assigned to one of the 9 large strata shown in Figure A-1A. Total transect length was computed for each stratum, season and survey type. For aerial surveys, effort was tabulated for sea states 4 and lower, and also for sea states 3 and lower. For shipboard surveys, effort was tabulated for sea states 5 and lower, and for 2 and lower.

Effective transect width (in meters) was defined in the reports associated with each survey:

NMFS Aerial Surveys	1,004
NMFS Ship Surveys (small cetaceans)	3,700
NMFS Ship Surveys (large cetaceans)	5,500
MMS High Aerial Surveys	1,480
MMS Low Aerial Surveys	180

Correction Factor for Survey Type

Because aerial and ship-based surveys detect different proportions of animals present and have different effective transect widths, aerial surveys were weighted differently than the same length of boat-based surveys when computing mean densities of animals in each stratum. In general, ship surveys detect a higher proportion of the mammals present, so a given length of ship survey provides a larger sample than the same length of aerial survey. Similarly the high altitude MMS aerial surveys allowed the observers to see a wider transect width and to scan a given portion of the sea surface for a longer period than did low altitude aerial surveys.

When two different kinds of surveys were combined to estimate density, a correction factor was applied to the sightings and effort associated with the survey having the wider effective transect width.

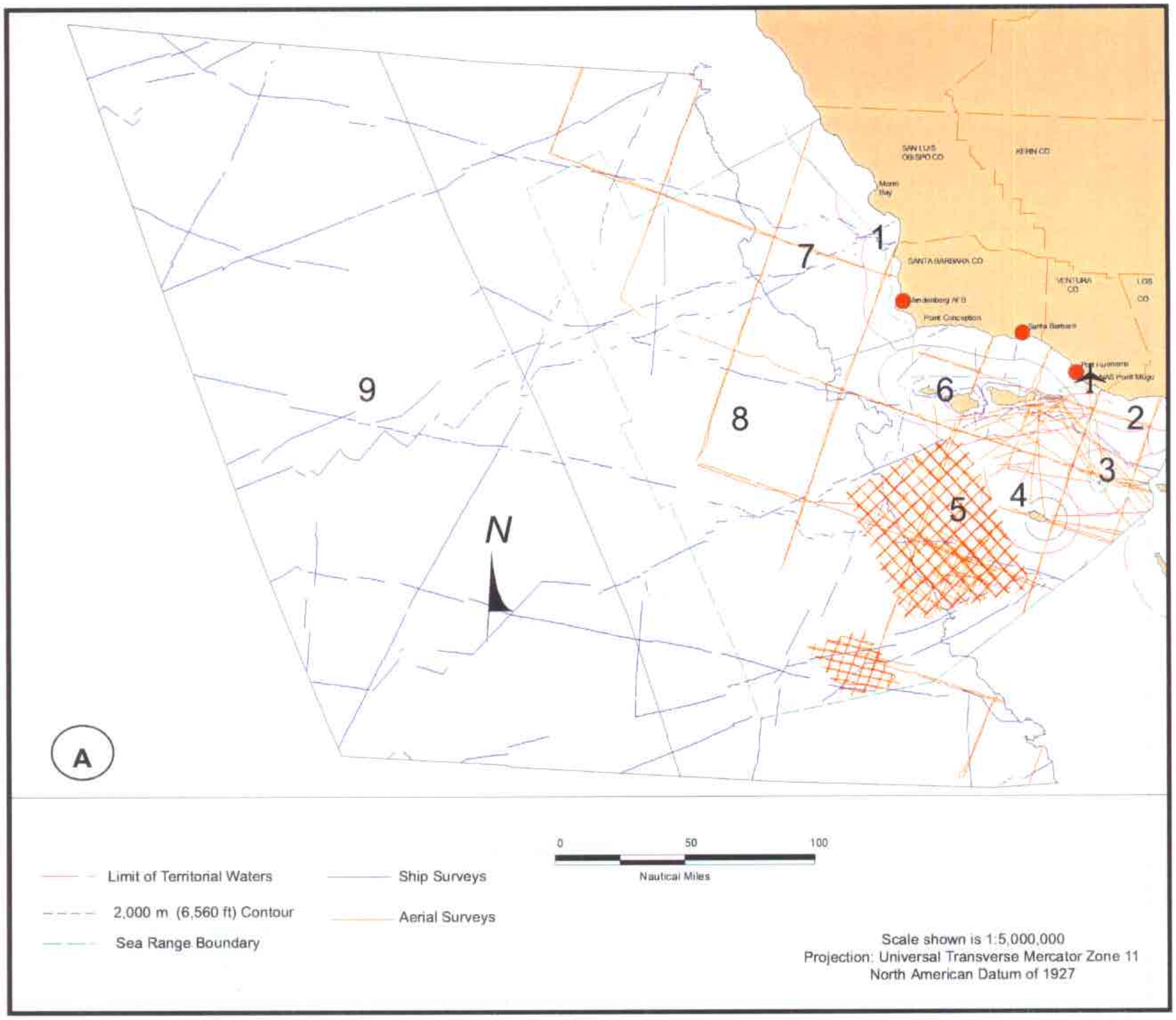


Figure A-2
Survey effort *(A)* by NMFS from 1991 to 1994 and *(B)* for BLM/MMS from 1975 to 1983 as used to calculate mean densities of marine mammals within each of the nine strata.

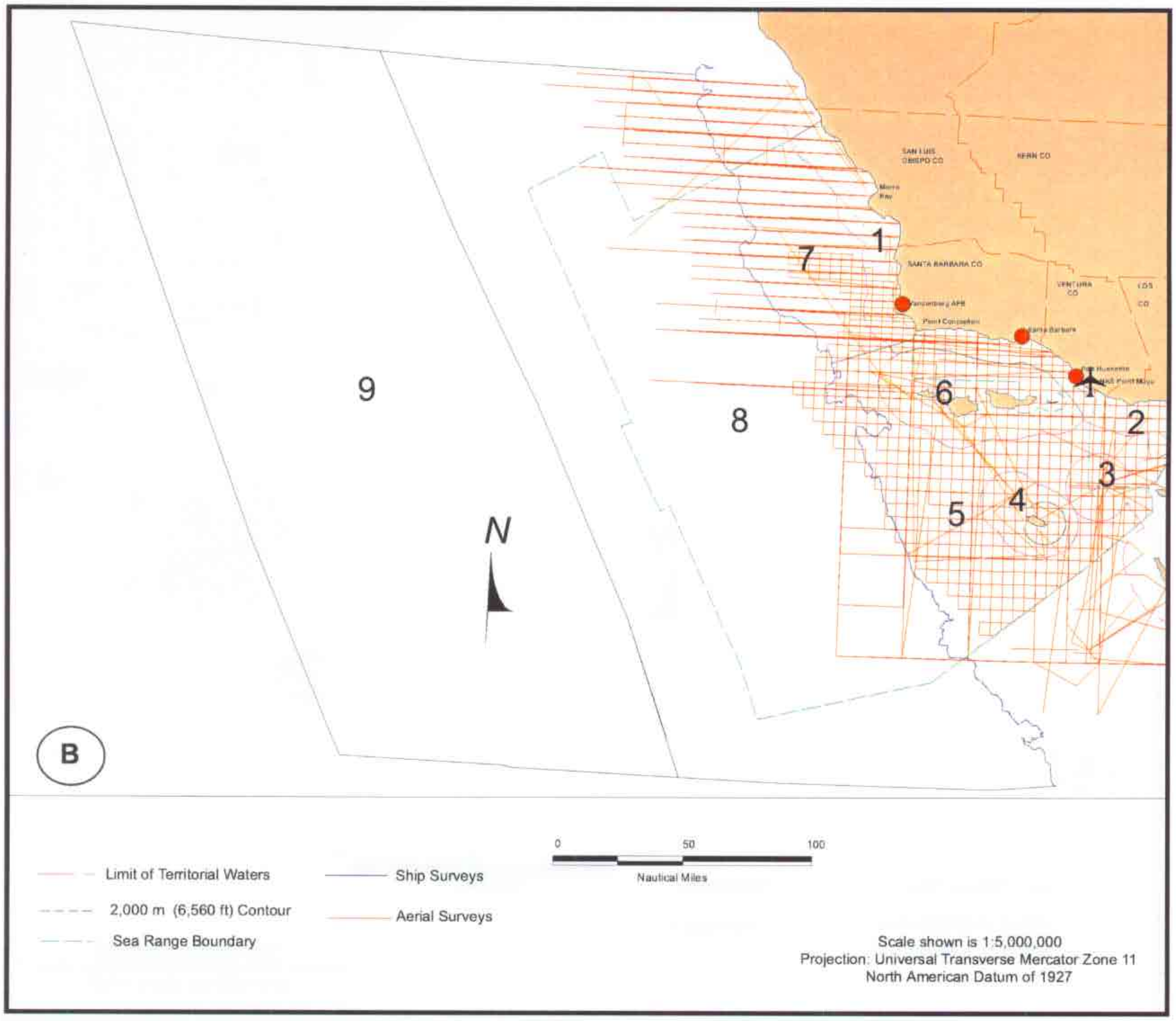


Figure A-2 (continued)
Survey effort *(A)* by NMFS from 1991 to 1994 and *(B)* for BLM/MMS from 1975 to 1983 as used to calculate mean densities of marine mammals within each of the nine strata.

A-3. Computation of Abundance

Cetaceans

In most cases, only the NMFS date set was used to compute abundance of cetaceans. A total of 579 sightings of cetaceans were recorded within the area shown in Figure A-1A as on-effort, on-transect and within allowable sea-state limits. Abundance of cetaceans was computed in the following manner:

- sightings were "corrected" for $f(0)$ and $g_{a,d}(0)$ and multiplied by the group size for the season and survey type,
- ship sightings were "corrected" for the larger transect width,
- "corrected" sightings were tabulated for each stratum and season,
- linear effort was multiplied by the "Survey Type" correction factor,
- effort was tabulated for each season and stratum, taking into account the sea-state limits for each species,
- "corrected" sightings were divided by effort to obtain densities in each stratum (Figure A-1A) and season,
- densities for each species in each season were multiplied by the area of each Sea Range stratum (Figure A-1B) to obtain abundance estimates by stratum.

BLM/MMS data were not used directly to estimate numbers of cetaceans in the Sea Range, largely because of concern about population and distributional changes since the BLM/MMS data were collected. However, the BLM/MMS data were used indirectly to estimate numbers of cetaceans during periods when NMFS/SWFSC surveys did not provide sufficient survey effort in a stratum to compute densities directly from NMFS/SWFSC survey data (see "Final Abundance Estimates", below). Some species move through or into and out of the Sea Range at different times of year. Others are resident there year round. To aid in the interpretation of seasonal changes in cetacean distributions, we supplemented the abundance data derived from the small but recent NMFS date set by computing *relative densities and abundance* in different seasons from the larger but less recent BLM/MMS date set. There were a total of 1,216 BLM/MMS sightings of cetaceans in the area shown in Figure A-1A.

Computations of relative abundance from the BLM/MMS date set were done in a manner similar to that described for the NMFS data. Sea state was not recorded for many of the MMS sightings and for many of the effort data.

Relative abundance of cetaceans was computed in the following manner:

- sightings were "corrected" for $f(0)$ and $g_{a,d}(0)$ and multiplied by group size for the appropriate season and survey type,
- high altitude sightings were "corrected" for the larger sightability factor,
- corrected sightings were tabulated for each stratum and season,
- linear effort was multiplied by transect width and high altitude effort was "corrected" for the larger sightability factor,
- effort was tabulated for each season and stratum,
- "corrected" sightings were divided by corrected effort to obtain densities in each stratum (Figure A-1A) and season, and
- densities for each species in each season were multiplied by the area of each Sea Range stratum (Figure A-1B) to obtain abundance estimates.

The correction for sightability was high altitude transect width divided by low altitude transect width.

Pinnipeds

The NMFS data do not adequately reflect the abundance of pinnipeds because pinnipeds were not recorded by NMFS in coastal or nearshore areas. Abundance of pinnipeds was computed using the BLM/MMS low altitude aerial surveys in all strata and the NMFS shipboard surveys in strata 5, 7 and 8. A total of 1,467 pinnipeds were recorded on-effort, on-transect and within allowable sea state limits during these surveys within the area shown in Figure A-1A. The procedure was as described above, with the following exceptions:

- a correction factor for year of survey, as described below, was applied to correct for increasing population sizes in recent years, and
- the "Survey Type" correction factor applied to the ship sightings and effort was the ship transect width divided by the low altitude aerial survey transect width.

There have been substantial changes in abundance of some species of pinnipeds over the period from which survey data are being summarized. This period began with the BLM/MMS surveys in 1975-1978 (southern California) and 1980-1983 (central California) and ends with the ongoing OSPR surveys. At least for pinnipeds, we needed to use the early survey data because they provide most of the available data on seasonal and geographic differences in abundance. Sample size is a limiting factor for many of the analyses that must be conducted. We "corrected" all pinniped sightings for changes in abundance between the year of the survey and 1995 by applying independently-derived population trend data, which are well defined for pinnipeds. The population trend data for the four common species of pinnipeds were from the following documents:

- harbor seal, Hanan (1996),
- northern fur seal, Barlow et al. (1997),
- California sea lion, Lowry (1992) and
- northern elephant seal, Lowry et al. (1996).

The data were scaled to the 1995 population sizes because 1995 was the latest year for which census data were available for most pinniped species in the Sea Range.

Final Abundance Estimates

The final abundance estimates for pinnipeds came from the procedures described above. However, for cetaceans, where the primary source of data was the recent NMFS/SWFSC data, there were sometimes too few data to estimate numbers of marine mammals present in some strata during some seasons. Survey effort was very limited during spring and autumn, and was sometimes limited in the small coastal strata during summer and winter as well. Using the methods described above, tables were produced for cetacean species that gave abundance estimates (using recent NMFS/SWFSC data) and relative abundance estimates (using BLM/MMS data) in each stratum during each season. Tables were also produced that gave "adjusted survey effort" contributing to each estimate. If the "adjusted effort" used to compute abundance estimates during NMFS surveys was <250 km, then that abundance estimate was replaced by an estimate that took the BLM/MMS data into account. The replacement estimate was based on the proportion of the Sea Range population occurring in each stratum according to the BLM/MMS data and the current population size in other strata in the Sea Range during that season according to the recent NMFS data. For spring and autumn, when few NMFS data were available for any strata, the following procedure was used:

(a) the summer and winter estimates of abundance in the Sea Range based on NMFS/SWFSC data were averaged,
(b) the proportions of animals present in each stratum in the Sea Range were estimated using BLM/MMS data for that season,
(c) the total number of animals present during the season of interest and during the average of winter plus summer were computed using the BLM/MMS data,
(d) the numbers from (a) and (c) were used to estimate the number present in the Sea Range during the season of interest, and
(e) the number calculated in (d) was prorated by the numbers in (b) to compute the number present in each stratum.

A few of the seasonal estimates that were based on single sightings within strata with >250 km of effort appeared unrealistically high or low. In consultation with NMFS/SWFSC, these point estimates were replaced with estimates incorporating BLM/MMS data. These replacement estimates were calculated as described above for strata with <250 km effort.

Confidence Limits

Coefficients of variation (CVs) were estimated for each seasonal estimate based on the number of sightings that contributed to the estimate. (The coefficient of variation is a measure of uncertainty calculated by dividing the standard error of estimate by the best available point estimate.) The method used here was suggested by NMFS/SWFSC and is based on data in Forney and Barlow (1998). There is a strong correlation between the CV of an estimate and the logarithm of the number of sightings that contributed to the estimate ($r = -0.862$, Figure A-3). The following formula was used to estimate the CV for each estimate:

$$CV = 0.94 - 0.162\log_e n$$

where n is the number of sightings contributing to the estimate.

Readers are cautioned that the CVs calculated in this manner may understate the uncertainty associated with the estimates, particularly when n is small. The survey effort that contributed to each of the estimates is highly variable and the day-to-day distribution of animals is sometimes highly variable due to changes in the distribution of their prey.

Density Estimates

Table A-1 shows the estimated densities of marine mammals for the various strata shown in Figure A-1.

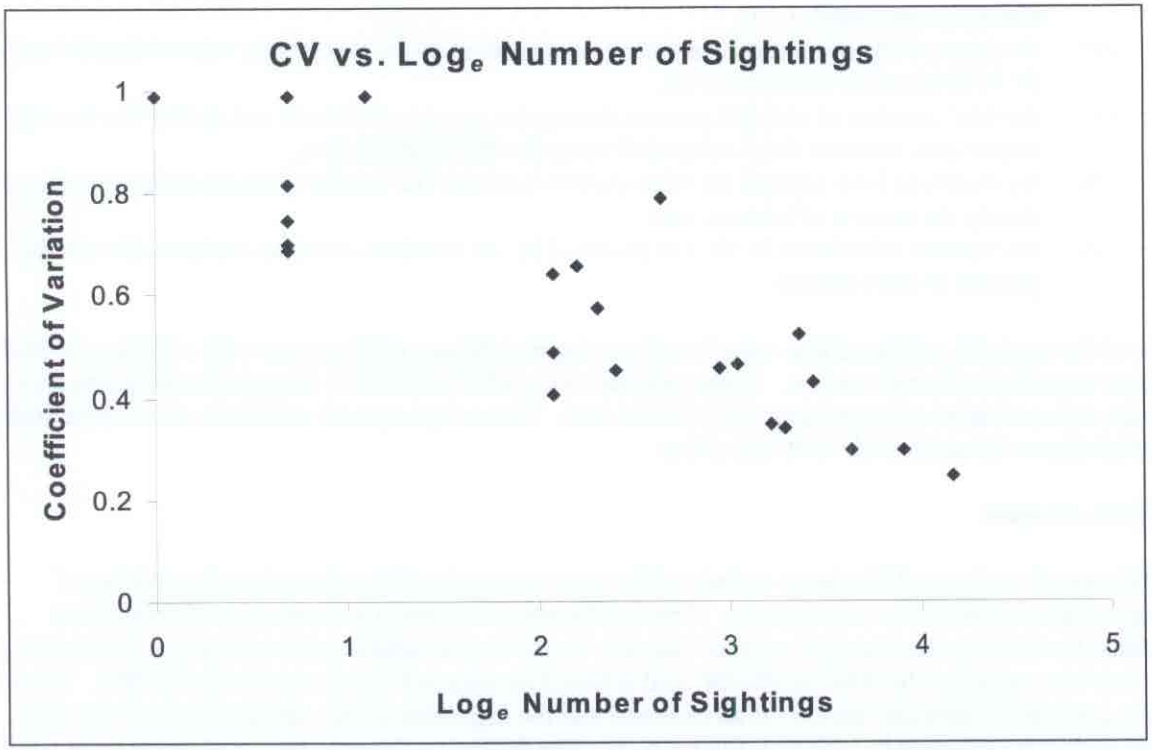


Figure A-3
Coefficient of Variation (CV) vs. logarithm$_e$ of the number of sightings for estimates of the number of animals present in a survey area.
Data from Table 3 of Forney and Barlow (1998).

Table A-1. Estimated Densities of Marine Mammals (number/km^2) and Coefficients of Variation (in parenthesis) of Each Species Present in the Point Mugu Sea Range During Each Oceanographic Season. The estimated densities incorporate estimates of availability bias. Densities in bold type are based on NMFS/SWFSC and MMS/BLM data. All CVs* are underestimated because they did not include estimates of the variance associated with diving behavior. All CVs for estimates using both NMFS/SWFSC and MMS/BLM data have additional uncertainty associated with combining the data from different survey methods and from different time periods.

	February-April		May-July		August-October		November-January	
Stratum	**No./km^2**	**C.V.**	**No./km^2**	**C.V.**	**No./km^2**	**C.V.**	**No./km^2**	**C.V.**
Harbor porpoise								
1	**0.10608**	(0.86)	**0.04793**	**(0.99)**	**0.05198**	(0.98)	**0.11687**	(0.84)
5	0.00000	(>1.00)	0.00000	**(>1.00)**	0.00000	(>1.00)	0.00000	(>1.00)
6 (2, 3, 4, 6)	0.00000	(>1.00)	**0.00000**	**(>1.00)**	**0.00000**	(>1.00)	**0.00000**	(>1.00)
7	**0.00000**	(>1.00)	**0.00000**	**(>1.00)**	**0.00000**	(>1.00)	**0.00000**	(>1.00)
8	0.00000	(>1.00)	0.00000	**(>1.00)**	0.00000	(>1.00)	0.00000	(>1.00)
All Strata	**0.00202**	(>0.86)	**0.00091**	**(>0.99)**	0.00099	(>0.98)	**0.00223**	(>0.84)
Dall's porpoise								
1	**0.10189**	(1.33)	**0.17520**	(0.49)	**0.16287**	(0.60)	**0.14634**	(0.54)
5	0.10189	(0.74)	0.05256	(0.83)	0.04129	(0.94)	0.16945	(0.68)
6 (2, 3, 4, 6)	0.10189	(0.82)	**0.16912**	(1.05)	**0.13346**	(1.07)	**0.14245**	(0.95)
7	**0.10189**	(1.12)	**0.10928**	(0.48)	**0.03293**	(1.27)	**0.09903**	(0.55)
8	0.10189	(0.83)	0.00000	(>1.00)	0.00000	(>1.00)	0.06068	(1.08)
All Strata	**0.10189**	(0.54)	**0.04035**	(>0.50)	0.02696	(>0.60)	**0.09350**	(0.50)
Pacific white-sided dolphin								
1	**0.05815**	(1.46)	**0.02109**	(0.83)	0.00000	(>1.00)	**0.09836**	(0.72)
5	0.40703	(0.68)	0.42818	(0.63)	0.00000	(>1.00)	0.41177	(0.68)
6 (2, 3, 4, 6)	0.00000	(>1.00)	**0.32262**	(1.08)	0.02328	(0.94)	1.00227	(0.83)
7	1.06252	(0.94)	**0.25636**	(0.48)	0.06678	(0.94)	**0.22862**	(0.45)
8	0.10748	(0.76)	0.27307	(0.83)	0.00227	(0.94)	**0.11271**	(1.10)
All Strata	**0.24414**	(>0.50)	**0.29894**	(0.50)	0.01036	(>0.65)	**0.26531**	(0.46)
Risso's dolphin								
1	**0.19529**	(1.26)	**0.04196**	(0.94)	**0.14649**	(1.40)	**0.25369**	(0.76)
5	0.59335	(0.63)	0.27931	(0.68)	0.08831	(0.76)	0.69258	(0.57)
6 (2, 3, 4, 6)	0.85487	(0.65)	**0.00000**	(>1.00)	0.46926	(0.65)	**0.08278**	(1.27)
7	0.35979	(0.94)	**0.52688**	(0.48)	0.33361	(0.76)	**1.25914**	(0.36)
8	0.33922	(0.83)	0.09180	(0.76)	0.04384	(0.59)	**0.31043**	(0.93)
All Strata	**0.43472**	(0.45)	**0.15830**	(0.38)	0.12488	(0.35)	**0.44898**	(0.43)
Bottlenose dolphin								
1	**0.00000**	(>1.00)	**0.00000**	(>1.00)	0.00000	(>1.00)	**0.00000**	(>1.00)
5	0.03240	(0.94)	0.00000	(>1.00)	0.05652	(0.76)	0.03278	(0.94)
6 (2, 3, 4, 6)	0.00000	(>1.00)	0.00000	(>1.00)	0.19157	(0.65)	**0.04412**	(1.16)
7	0.00000	(>1.00)	**0.00000**	(>1.00)	0.00000	(>1.00)	**0.00000**	(>1.00)
8	0.00000	(>1.00)	0.00000	(>1.00)	0.00415	(0.83)	0.00000	(>1.00)
All Strata	**0.00573**	(>0.94)	**0.00000**	(>1.00)	0.03155	(>0.47)	**0.01018**	(>0.73)

Table A-1. Estimated Densities of Marine Mammals (number/km²) and Coefficients of Variation (in parenthesis) of Each Species Present in the Point Mugu Sea Range During Each Oceanographic Season (continued).

	February-April		May-July		August-October		November-January	
Stratum	No./km²	C.V.	No./km²	C.V.	No./km²	C.V.	No./km²	C.V.
Common dolphin								
1	23.33505	(0.83)	14.46994	(>1.00)	7.66789	(0.76)	14.46994	(>1.00)
5	1.42719	(0.65)	1.77636	(0.39)	1.00386	(0.54)	2.44465	(0.63)
6 (2, 3, 4, 6)	8.21981	(0.63)	9.01302	(0.68)	7.28223	(0.48)	6.82394	(0.76)
7	2.90402	(0.94)	1.41911	(>1.00)	0.51117	(0.76)	1.41911	(>1.00)
8	0.92809	(0.72)	1.56338	(0.41)	0.92227	(0.23)	1.61623	(0.83)
All Strata	2.36543	(0.34)	2.57319	(>0.28)	1.65650	(0.24)	2.50564	(>0.40)
Northern right whale dolphin								
1	**0.17436**	(1.40)	**0.01741**	(0.94)	**0.19599**	(1.33)	**0.09484**	(0.83)
5	2.39314	(0.48)	1.57550	(0.68)	0.00000	(>1.00)	0.33666	(0.60)
6 (2, 3, 4, 6)	0.59887	(0.83)	**0.02155**	(1.57)	0.00000	(>1.00)	**0.14112**	(1.25)
7	2.28260	(0.94)	**0.28256**	(0.53)	0.00000	(>1.00)	**0.19449**	(0.49)
8	0.36474	(0.83)	0.86773	(0.76)	-0.06577	(0.68)	**0.11586**	(1.19)
All Strata	**0.93440**	(0.38)	**0.83408**	(0.53)	**0.04352**	(>0.63)	**0.16485**	(0.56)
Cuvier's beaked whale								
1	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
5	0.02487	(0.66)	0.02487	(0.66)	0.02487	(0.66)	0.02487	(0.66)
6 (2, 3, 4, 6)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
7	0.02487	(1.11)	0.02487	(1.11)	0.02487	(1.11)	0.02487	(1.11)
8	0.02487	(0.71)	0.02487	(0.71)	0.02487	(0.71)	0.02487	(0.71)
All Strata	0.02193	(>0.52)	0.02193	(>0.52)	0.02193	(>0.52)	0.02193	(>0.52)
Sperm whale								
1	**0.00000**	(>1.00)	**0.00000**	(>1.00)	**0.00000**	(>1.00)	**0.00000**	(>1.00)
5	0.03835	(0.76)	0.00000	(>1.00)	0.01254	(0.94)	0.00000	(>1.00)
6 (2, 3, 4, 6)	0.00000	(>1.00)	**0.00000**	(>1.00)	0.00000	(>1.00)	**0.00000**	(>1.00)
7	0.00000	(>1.00)	**0.00000**	(>1.00)	0.00000	(>1.00)	**0.03247**	(0.83)
8	0.05517	(0.72)	0.00000	(>1.00)	0.00245	(0.68)	0.08352	(0.83)
All Strata	**0.04015**	(>0.61)	**0.00000**	(>1.00)	0.00370	(>0.63)	**0.05376**	(>0.78)
Striped dolphin								
1	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
5	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
6 (2, 3, 4, 6)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
7	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
8	0.00000	(>1.00)	0.08164	(0.94)	0.13983	(0.57)	0.00000	(>1.00)
All Strata	0.00000	(>1.00)	0.04938	(>0.94)	0.08459	(>0.57)	0.00000	(>1.00)
Killer whale								
1	0.00387	(1.37)	0.00387	(1.37)	0.00387	(1.37)	0.00387	(1.37)
5	0.00387	(0.84)	0.00387	(0.84)	0.00387	(0.84)	0.00387	(0.84)
6 (2, 3, 4, 6)	0.00387	(1.01)	0.00387	(1.01)	0.00387	(1.01)	0.00387	(1.01)
7	0.00387	(1.24)	0.00387	(1.24)	0.00387	(1.24)	0.00387	(1.24)
8	0.00387	(0.71)	0.00387	(0.71)	0.00387	(0.71)	0.00387	(0.71)
All Strata	0.00387	(0.48)	0.00387	(0.48)	0.00387	(0.48)	0.00387	(0.48)

Table A-1. Estimated Densities of Marine Mammals (number/km²) and Coefficients of Variation (in parenthesis) of Each Species Present in the Point Mugu Sea Range During Each Oceanographic Season (continued).

	February-April		May-July		August-October		November-January	
Stratum	**No./km²**	**C.V.**	**No./km²**	**C.V.**	**No./km²**	**C.V.**	**No./km²**	**C.V.**
Baird's beaked whale								
1	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
5	0.00180	(0.92)	0.00180	(0.92)	0.00180	(0.92)	0.00180	(0.92)
6 (2, 3, 4, 6)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
7	0.00180	(1.37)	0.00180	(1.37)	0.00180	(1.37)	0.00180	(1.37)
8	0.00180	(0.97)	0.00180	(0.97)	0.00180	(0.97)	0.00180	(0.97)
All Strata	0.00159	(>0.71)	0.00159	(>0.71)	0.00159	(>0.71)	0.00159	(>0.71)
Other beaked whales								
1	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
5	0.00697	(0.92)	0.00697	(0.92)	0.00697	(0.92)	0.00697	(0.92)
6 (2, 3, 4, 6)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
7	0.00697	(1.37)	0.00697	(1.37)	0.00697	(1.37)	0.00697	(1.37)
8	0.00697	(0.97)	0.00697	(0.97)	0.00697	(0.97)	0.00697	(0.97)
All Strata	0.00614	(>0.71)	0.00614	(>0.71)	0.00614	(>0.71)	0.00614	(>0.71)
Humpback whale								
1	**0.00000**	(>1.00)	**0.00475**	(0.83)	0.02334	(0.94)	**0.00000**	(>1.00)
5	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
6 (2, 3, 4, 6)	0.00000	(>1.00)	0.00000	(>1.00)	0.00640	(0.83)	0.00000	(>1.00)
7	0.00000	(>1.00)	**0.01257**	(0.63)	0.00904	(0.94)	**0.00137**	(0.94)
8	0.00000	(>1.00)	0.00000	(>1.00)	0.00062	(0.83)	0.00000	(>1.00)
All Strata	**0.00000**	(>1.00)	**0.00135**	(>0.59)	0.00236	(>0.48)	**0.00014**	(>0.94)
Gray whale								
1	**0.42056**	(0.77)	**0.03409**	(0.63)	0.00000	(>1.00)	**0.49440**	(0.26)
5	0.03376	(0.72)	0.00000	(>1.00)	0.00000	(>1.00)	0.00997	(0.94)
6 (2, 3, 4, 6)	0.10326	(0.68)	0.00000	(>1.00)	0.00000	(>1.00)	0.06765	(0.94)
7	**0.00904**	(1.33)	**0.00000**	(>1.00)	0.00000	(>1.00)	**0.00831**	(0.83)
8	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
All Strata	**0.02515**	(>0.41)	**0.00065**	(>0.63)	0.00000	(>1.00)	**0.01874**	(>0.37)
Blue whale								
1	**0.00000**	(>1.00)	**0.01988**	(>1.00)	0.00000	(>1.00)	**0.00000**	(>1.00)
5	0.00000	(>1.00)	0.01426	(0.63)	0.02650	(0.60)	0.00000	(>1.00)
6 (2, 3, 4, 6)	0.00000	(>1.00)	0.00000	(>1.00)	0.01453	(0.72)	0.00000	(>1.00)
7	0.00000	(>1.00)	**0.00000**	(>1.00)	0.05140	(0.65)	**0.00000**	(>1.00)
8	0.00471	(0.94)	0.01710	(0.63)	0.00997	(0.37)	0.00000	(>1.00)
All Strata	**0.00285**	(>0.94)	**0.01325**	(>0.51)	0.01729	(>0.29)	**0.00000**	(>1.00)
Fin whale								
1	**0.00000**	(>1.00)	**0.00647**	(0.94)	0.00000	(>1.00)	**0.00000**	(>1.00)
5	0.01591	(0.72)	0.01035	(0.72)	0.02342	(0.65)	0.01207	(0.76)
6 (2, 3, 4, 6)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.02731	(0.94)
7	0.00000	(>1.00)	**0.00000**	(>1.00)	0.09709	(0.54)	**0.00429**	(0.94)
8	0.00000	(>1.00)	0.00000	(>1.00)	0.00332	(0.54)	0.00000	(>1.00)
All Strata	**0.00281**	(>0.72)	**0.00195**	(>0.68)	0.01584	(>0.38)	**0.00528**	(>0.58)

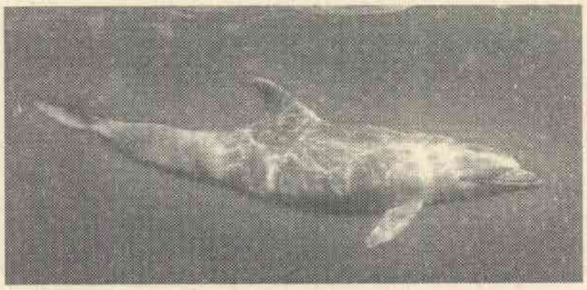
Table A-1. Estimated Densities of Marine Mammals (number/km²) and Coefficients of Variation (in parenthesis) of Each Species Present in the Point Mugu Sea Range During Each Oceanographic Season (continued).

	February-April		May-July		August-October		November-January	
Stratum	No./km²	C.V.	No./km²	C.V.	No./km²	C.V.	No./km²	C.V.
Sei whale								
1	**0.00000**	(>1.00)	**0.00000**	(>1.00)	0.00000	(>1.00)	**0.00000**	(>1.00)
5	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
6 (2, 3, 4, 6)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
7	0.00000	(>1.00)	**0.00000**	(>1.00)	0.00000	(>1.00)	**0.00000**	(>1.00)
8	0.00000	(>1.00)	0.00000	(>1.00)	0.00016	(0.94)	0.00000	(>1.00)
All Strata	**0.00000**	(>1.00)	**0.00000**	(>1.00)	0.00010	(>0.94)	**0.00000**	(>1.00)
Minke whale								
1	0.00192	(1.31)	0.00192	(1.31)	0.00192	(1.31)	0.00192	(1.31)
5	0.00192	(0.80)	0.00192	(0.80)	0.00192	(0.80)	0.00192	(0.80)
6 (2, 3, 4, 6)	0.00192	(1.03)	0.00192	(1.03)	0.00192	(1.03)	0.00192	(1.03)
7	0.00192	(1.25)	0.00192	(1.25)	0.00192	(1.25)	0.00192	(1.25)
8	0.00192	(0.85)	0.00192	(0.85)	0.00192	(0.85)	0.00192	(0.85)
All Strata	0.00192	(0.68)	0.00192	(0.68)	0.00192	(0.68)	0.00192	(0.68)
Harbor seal								
1	0.16218	(0.65)	0.02184	(0.94)	0.02336	(0.94)	0.05307	(0.94)
2	0.06432	(0.94)	0.27560	(0.83)	0.00000	(>1.00)	0.41884	(0.72)
3	0.00000	(>1.00)	0.38638	(0.94)	0.00000	(>1.00)	0.00000	(>1.00)
4	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
5	0.00000	(>1.00)	0.05061	(0.94)	0.03769	(0.94)	0.00000	(>1.00)
6	0.13117	(0.94)	0.29600	(0.76)	0.05748	(0.94)	0.39558	(0.72)
7	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
8	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
All Strata	0.00981	(>0.65)	0.03067	(>0.49)	0.00994	(>0.69)	0.02214	(>0.64)
Northern elephant seal								
1	0.00000	(>1.00)	0.15205	(0.83)	0.15493	(0.68)	0.48638	(0.68)
2	0.31211	(0.94)	0.00000	(>1.00)	0.34894	(0.83)	0.00000	(>1.00)
3	1.71193	(0.83)	0.00000	(>1.00)	0.57295	(0.94)	0.64088	(0.94)
4	1.56227	(0.94)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
5	0.58278	(0.76)	0.00000	(>1.00)	0.07437	(0.65)	0.18958	(0.83)
6	0.47188	(0.83)	0.80635	(0.76)	0.09452	(0.94)	0.00000	(>1.00)
7	0.18144	(0.72)	0.27061	(0.65)	0.07224	(0.65)	0.09540	(0.83)
8	0.10827	(0.83)	0.00000	(>1.00)	0.06903	(0.53)	0.09939	(0.83)
All Strata	0.28551	(>0.39)	0.06966	(>0.50)	0.07946	(>0.33)	0.12179	(>0.48)
California sea lion								
1	1.20327	(0.35)	4.62960	(0.27)	1.50389	(0.25)	2.60351	(0.28)
2	2.12053	(0.43)	13.73869	(0.29)	4.61864	(0.28)	2.70838	(0.36)
3	1.96798	(0.65)	6.31971	(0.57)	5.43780	(0.42)	5.63699	(0.43)
4	2.74751	(0.72)	4.71374	(0.65)	5.88287	(0.42)	5.29362	(0.50)
5	0.13008	(0.83)	3.24533	(0.38)	1.16072	(0.32)	1.54458	(0.36)
6	1.95824	(0.47)	11.29354	(0.31)	3.58401	(0.19)	4.14797	(0.29)
7	0.33133	(0.47)	1.60679	(0.34)	0.70401	(0.31)	0.96698	(0.35)
8	0.30682	(0.53)	0.13171	(0.83)	0.01794	(0.60)	0.90397	(0.43)
All Strata	0.48503	(0.27)	1.75356	(0.18)	0.77511	(0.15)	1.43078	(0.20)

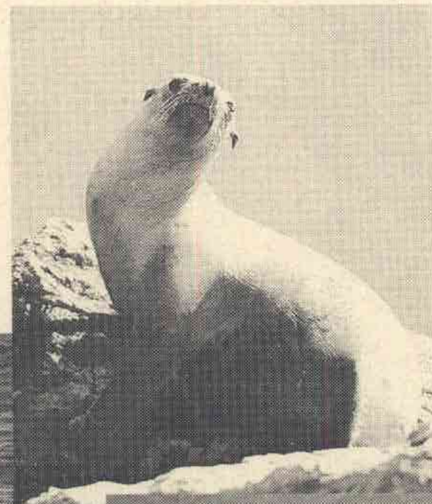
Table A-1. Estimated Densities of Marine Mammals (number/km^2) and Coefficients of Variation (in parenthesis) of Each Species Present in the Point Mugu Sea Range During Each Oceanographic Season (continued).

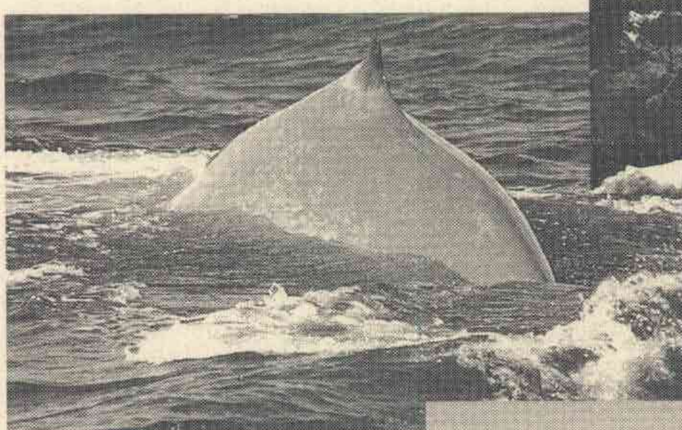
	February-April		May-July		August-October		November-January	
Stratum	No./km^2	C.V.	No./km^2	C.V.	No./km^2	C.V.	No./km^2	C.V.
Northern fur seal								
1	0.07088	(0.68)	0.02017	(0.83)	0.03095	(0.65)	0.01491	(0.94)
2	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.02412	(0.94)
3	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)
4	0.00000	(>1.00)	0.00000	(>1.00)	0.00000	(>1.00)	0.13748	(0.94)
5	0.32509	(0.57)	0.01583	(0.94)	0.00000	(>1.00)	0.14446	(0.57)
6	0.14828	(0.76)	0.00000	(>1.00)	0.03043	(0.83)	0.00000	(>1.00)
7	0.48312	(0.28)	0.12967	(0.43)	0.11028	(0.39)	0.05241	(0.63)
8	0.60237	(0.28)	0.04121	(0.72)	0.02360	(0.50)	0.34756	(0.41)
All Strata	0.47875	(>0.23)	0.04106	(>0.46)	0.02738	(>0.31)	0.24574	(>0.36)

* CV (coefficient of variation) is a measure of a number's variability. The larger the CV, the higher the variability.



Appendix B





APPENDIX B
ESTIMATES OF NUMBERS OF MARINE MAMMALS AT SEA THAT MIGHT BE INJURED OR KILLED

General Approach

The numbers of marine mammals that may be injured or killed annually by current and proposed Navy activities were estimated based on the densities of marine mammals in the areas where these activities are conducted, the numbers of activities, and the area of influence of the activity. The number of operations conducted in FY95 was used as the basis for Current Operations. Table B-1A shows the number of missiles and targets deployed, the stratum where they were terminated in the ocean (see Figure A-1 for stratum boundaries), and whether: (1) they were assumed to have been destroyed and contributed to debris, or (2) they were assumed to enter the water intact. As described in Section 4.7.2.1-C, all missiles and targets expected to impact the water's surface within the Point Mugu Sea Range were subdivided into five categories of vehicles based on their mass, surface area, and speed. For simplicity, these are categorized here as "Phoenix-type" (medium-sized supersonic), "Harpoon-type" (subsonic), "AQM-37/Sidewinder type" (smaller supersonic), Vandal, and "AltAir type" (larger ballistic). Table B-1B shows these assumptions for the proposed theater missile defense events (excluding nearshore intercept events). Table B-1C shows these assumptions for the proposed nearshore intercept events. Table B-1D shows these assumptions for the proposed additional Fleet Exercise (FLEETEX). These tables prorate the numbers of missiles and targets terminating in each stratum based on FY95 deployment.

The following sections give the basic assumptions and methods used for estimating injury or mortality due to each type of potential effect.

Injury or mortality from missile debris

For debris, the area of the sea surface subject to missile and target debris was assumed to be the same as the surface area of the missile or target. The surface area of the debris from all targets and missiles that terminated in each stratum was then used to compute the number of marine mammals that would be hit by debris. Table B-2 is an example of the computations for all Current Operations. Table B-3 is an example for the proposed additional FLEETEX. Table B-4 is an example for the proposed nearshore intercept events. Table B-5 is an example for the proposed theater missile defense (TMD) events (including three types of TMD events, with three events per year of each type). In these tables the first sub-table describes the area of sea surface hit by debris or the area of influence of the effect. The next four sub-tables (one for nearshore intercept) estimate the numbers of each species injured or killed by debris, or within the radius of influence of the effect, for each of the Sea Range strata (Figure A-1) under consideration. These estimates are based on the density of each species in the stratum (shown to the left of the sub-table and as calculated in Appendix A), the proportion at the surface or below the surface, and the area of influence of each effect (from the first sub-table). A summary is presented at the bottom of each table. In some cases, such as animals being struck by debris, we are concerned only with animals at or near the surface. The summary also shows the breakdown of effects in territorial and *non-territorial waters*.

Injury or mortality from inert mine drops

For inert mine drops, the area of sea surface hit by a mine was assumed to be a circle with radius 3.3 feet (1 meter) for small cetaceans and pinnipeds and a circle with radius 13 feet (4 meters) for large cetaceans.

Injury or mortality from Close-In Weapon System operations

For Close-In Weapon System (CIWS) operations, it was assumed that only animals at the surface could be injured or killed from being hit by CIWS rounds. Table B-6 shows an example of the computations for Current Operations (3,000 rounds per year).

Injury or mortality due to missile impact or shock waves

Intact missiles or targets hitting the water can injure or kill a marine mammal directly or indirectly through the shock waves created when it hits the water. The impulse created by the shock wave was estimated for each type of vehicle for various depths and distances using the equations presented in Section 4.7.1.2-C. The impulse criterion for death from shock waves for each species was estimated using Yelverton's (1981) equation (Section 4.7.1.5-A). The areal extent of damage was estimated for each species based on the criterion for mortality and the distance from the impact point within which this criterion was met.

Exposure to impulses causing temporary threshold shift

Sound exposure contours were computed for intact missiles and targets that hit the water using the equations presented in Section 4.7.1.2-C. TTS criteria are specified in Section 4.7.1.1 (Table 4.7-1). The area of influence was computed by estimating the distance from the source at which the sound level diminished below the TTS criterion for each kind of marine mammal. Because the impulse from an object hitting the water acts as a dipole type of source, the radius of influence is different at different water depths. Computations were made for animals at the surface and at depth. The average depth of marine mammals below the surface was assumed to be 162 feet (50 meters). Table B-7A gives an example calculation of the number of marine mammals below the surface that are subjected to TTS and Table B-7B gives the calculation for animals at or near the surface. Table B-7C gives the calculation for the numbers of seals with their heads above the water that may experience TTS due to CIWS gun firing.

Table B-1. Assumed disposition and area of termination for missiles and targets deployed duri Current Operations, Theater Missile Defense, Nearshore Intercept, and Additional FLEETEX.

A. Current Operations (FY95)

Missiles and targets terminating in each stratum

	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Stratum 4	10.8	6.1	5.0	0.0	0.8
Stratum 5	86.4	48.6	40.4	0.0	6.4
Stratum 6	10.8	6.1	5.0	0.0	0.8
Stratum 8	97.0	44.3	15.5	8.0	0.0
Total	205.0	105.0	66.0	8.0	8.0
Total Missiles		271			
Missiles + Targets		392			

Missiles and targets contributing to debris

	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Stratum 4	8.1	1.3	3.1	0.0	0.4
Stratum 5	64.8	10.1	24.6	0.0	2.8
Stratum 6	8.1	1.3	3.1	0.0	0.4
Stratum 8	72.8	3.3	5.2	0.0	0.0
Total	153.8	16.0	36.0	0.0	3.5
Total Missiles		201.0			
Missiles + Targets		210.0			

Missiles and targets landing intact

	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Stratum 4	2.7	1.2	1.2	0.0	0.4
Stratum 5	21.6	9.2	9.5	0.0	2.8
Stratum 6	2.7	1.2	1.2	0.0	0.4
Stratum 8	24.3	7.8	3.2	8.0	0.0
Total	51	19	15	8	4
Total Missiles		70.0			
Missiles + Targets		98.0			

B. Theater Missile Defense (not including nearshore interc

Missiles and targets contributing to debris

	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Stratum 4	0.2	0.0	0.0	0.0	0.1
Stratum 5	2.5	0.0	0.0	0.0	2.2
Stratum 6	0.0	0.0	0.0	0.0	0.0
Stratum 8	6.3	0.0	0.0	0.0	2.3
Total	9.0	0.0	0.0	0.0	4.5
Total Missiles		13.5			
Missiles + Targets		13.5			

Missiles and targets landing intact

	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Stratum 4	0.1	0.0	0.0	0.0	0.1
Stratum 5	0.8	0.0	0.0	0.0	2.2
Stratum 6	0.0	0.0	0.0	0.0	0.0
Stratum 8	2.1	0.0	0.0	0.0	2.3
Total	3.0	0.0	0.0	0.0	4.5
Total Missiles		7.5			
Missiles + Targets		7.5			

C. Nearshore Intercept

Missiles and targets contributing to debris

	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Stratum 4	3.0	0.0	3.0	0.0	0.0
Stratum 5	0.0	0.0	0.0	0.0	0.0
Stratum 6	0.0	0.0	0.0	0.0	0.0
Stratum 8	0.0	0.0	0.0	0.0	0.0
Total	3.0	0.0	3.0	0.0	0.0
Total Missiles		3.0			
Missiles + Targets		6.0			

Missiles and targets landing intact

	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Stratum 4	1.0	0.0	1.0	0.0	0.0
Stratum 5	0.0	0.0	0.0	0.0	0.0
Stratum 6	0.0	0.0	0.0	0.0	0.0
Stratum 8	0.0	0.0	0.0	0.0	0.0
Total	1.0	0.0	1.0	0.0	0.0
Total Missiles		1.0			
Missiles + Targets		2.0			

D. Additional FLEETEX

Missiles and targets contributing to debris

	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Stratum 4	0.8	0.4	0.8	0.0	0.0
Stratum 5	6.8	3.5	7.5	0.0	0.0
Stratum 6	0.0	0.0	0.0	0.0	0.0
Stratum 8	6.0	0.9	0.1	0.0	0.0
Total	13.5	4.7	8.5	0.0	0.0
Total Missiles		24.8			
Missiles + Targets		26.7			

Missiles and targets landing intact

	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Stratum 4	0.3	0.3	0.3	0.2	0.0
Stratum 5	2.3	2.7	2.7	1.4	0.0
Stratum 6	0.0	0.0	0.0	0.0	0.0
Stratum 8	2.0	2.0	0.3	1.5	0.0
Total	4.5	5.0	3.3	3.0	0.0
Total Missiles		8.3			
Missiles + Targets		15.8			

Table B-2. Estimates of numbers of marine mammals that are struck by debris from missiles or targets: Current Operations.

Adults	Body Weight (kg)	Surface Area of Missile (m2) Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	11-100,000+	4.787	4.203	2.926	17.086	25.935
Sperm whale	15-48,000	4.787	4.203	2.926	17.086	25.935
Beaked Whales	2500	4.787	4.203	2.926	17.086	25.935
Killer whale	5000	4.787	4.203	2.926	17.086	25.935
Pilot whale	800	4.787	4.203	2.926	17.086	25.935
Risso's dolphin	300	4.787	4.203	2.926	17.086	25.935
Northern right whale dolphin	90	4.787	4.203	2.926	17.086	25.935
Bottlenose dolphin	200	4.787	4.203	2.926	17.086	25.935
White-sided dolphin	200	4.787	4.203	2.926	17.086	25.935
Common dolphin	75	4.787	4.203	2.926	17.086	25.935
Striped dolphin	125	4.787	4.203	2.926	17.086	25.935
Dall's porpoise	175	4.787	4.203	2.926	17.086	25.935
Harbor porpoise	64	4.787	4.203	2.926	17.086	25.935
California Sea Lion	200	4.787	4.203	2.926	17.086	25.935
Northern Fur Seal	150	4.787	4.203	2.926	17.086	25.935
Northern Elephant Seal	1000	4.787	4.203	2.926	17.086	25.935
Harbor Seal	65	4.787	4.203	2.926	17.086	25.935

Stratum 8

	Density	# animals Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	0.0109	0.00000	0.00000	0.00000	0.00000	0.00000
Sperm whale	0.0353	0.00000	0.00000	0.00000	0.00000	0.00000
Beaked Whales	0.0336	0.00000	0.00000	0.00000	0.00000	0.00000
Killer whale	0.0039	0.00000	0.00000	0.00000	0.00000	0.00000
Pilot whale	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
Risso's dolphin	0.1963	0.00000	0.00000	0.00000	0.00000	0.00001
Northern right whale dolphin	0.3535	0.00000	0.00000	0.00000	0.00001	0.00001
Bottlenose dolphin	0.0010	0.00000	0.00000	0.00000	0.00000	0.00000
White-sided dolphin	0.1239	0.00000	0.00000	0.00000	0.00000	0.00000
Common dolphin	1.2575	0.00001	0.00001	0.00000	0.00002	0.00003
Striped dolphin	0.0554	0.00000	0.00000	0.00000	0.00000	0.00000
Dall's porpoise	0.0406	0.00000	0.00000	0.00000	0.00000	0.00000
Harbor porpoise	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
California Sea Lion	0.4935	0.00000	0.00000	0.00000	0.00001	0.00001
Northern Fur Seal	0.2537	0.00000	0.00000	0.00000	0.00000	0.00001
Northern Elephant Seal	0.0692	0.00000	0.00000	0.00000	0.00000	0.00000
Harbor Seal	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
All Species		0.00001	0.00001	0.00001	0.00005	0.00008
No. of Missiles + Targets	**81.29**	72.75	3.32	5.21	0.00	0.00
Total Injury	**0.0011**	**0.0010**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

Stratum 5

	Density	# animals Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	0.0385	0.00000	0.00000	0.00000	0.00000	0.00000
Sperm whale	0.0127	0.00000	0.00000	0.00000	0.00000	0.00000
Beaked Whales	0.0336	0.00000	0.00000	0.00000	0.00000	0.00000
Killer whale	0.0039	0.00000	0.00000	0.00000	0.00000	0.00000
Pilot whale	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
Risso's dolphin	0.4134	0.00000	0.00000	0.00000	0.00001	0.00001
Northern right whale dolphin	1.0763	0.00001	0.00000	0.00000	0.00002	0.00003
Bottlenose dolphin	0.0304	0.00000	0.00000	0.00000	0.00000	0.00000
White-sided dolphin	0.3117	0.00000	0.00000	0.00000	0.00001	0.00001
Common dolphin	1.6630	0.00001	0.00001	0.00000	0.00003	0.00004
Striped dolphin	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
Dall's porpoise	0.0913	0.00000	0.00000	0.00000	0.00000	0.00000
Harbor porpoise	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
California Sea Lion	1.5852	0.00001	0.00001	0.00000	0.00003	0.00004
Northern Fur Seal	0.1213	0.00000	0.00000	0.00000	0.00000	0.00000
Northern Elephant Seal	0.2117	0.00000	0.00000	0.00000	0.00000	0.00001
Harbor Seal	0.0409	0.00000	0.00000	0.00000	0.00000	0.00000
All Species		0.00003	0.00002	0.00002	0.00010	0.00015
No. of Missiles + Targets	**102.35**	64.80	10.12	24.63	0.00	2.80
Total Injury	**0.0028**	**0.0017**	**0.0002**	**0.0004**	**0.0000**	**0.0004**

Surface area of each missile	2	2	2	2	2
Radius of missile	0.19	0.17	0.11	0.36	0.67
pi	3.1416	3.1416	3.1416	3.1416	3.1416
Height of missile	4.01	3.9	4.14	7.66	6.17
Surface area of missile	4.787	4.203	2.926	17.086	25.935

Assumptions:
- 25% of Sidewinder and standard type missiles land intact
- 50% of AltAir-sized missiles land intact
- 9 target vehicles contribute to debris (based on number of live wareheads in missiles)

Animals hit by debris	
Total missiles and targets	209.23
Total at and below surface	0.0058
g(0) =	0.354
Animals at surface	**0.0021**
Non-territorial waters	*0.0014*
Territorial waters	0.0007

Stratum 6

	Density	# animals Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.05671	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00387	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.35173	0.00000	0.00000	0.00000	0.00001	0.00001
	0.19038	0.00000	0.00000	0.00000	0.00000	0.00000
	0.05892	0.00000	0.00000	0.00000	0.00000	0.00000
	0.33704	0.00000	0.00000	0.00000	0.00001	0.00001
	7.83475	0.00004	0.00003	0.00002	0.00013	0.00020
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.10336	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	6.22506	0.00003	0.00003	0.00002	0.00011	0.00016
	0.04468	0.00000	0.00000	0.00000	0.00000	0.00000
	0.34319	0.00000	0.00000	0.00000	0.00001	0.00001
	0.24880	0.00000	0.00000	0.00000	0.00000	0.00001
All Species		0.00008	0.00007	0.00005	0.00027	0.00041
No. of Missiles + Targets	**12.79**	8.10	1.27	3.08	0.00	0.35
Total Injury	**0.0010**	**0.0006**	**0.0001**	**0.0001**	**0.0000**	**0.0001**

Stratum 4

	Density	# animals Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.0567	0.00000	0.00000	0.00000	0.00000	0.00000
	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.0039	0.00000	0.00000	0.00000	0.00000	0.00000
	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.3517	0.00000	0.00000	0.00000	0.00001	0.00001
	0.1904	0.00000	0.00000	0.00000	0.00000	0.00000
	0.0589	0.00000	0.00000	0.00000	0.00000	0.00000
	0.3370	0.00000	0.00000	0.00000	0.00001	0.00001
	7.8347	0.00004	0.00003	0.00002	0.00013	0.00020
	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.1034	0.00000	0.00000	0.00000	0.00000	0.00000
	0.0000	0.00000	0.00000	0.00000	0.00000	0.00000
	6.0332	0.00003	0.00003	0.00002	0.00010	0.00016
	0.0344	0.00000	0.00000	0.00000	0.00000	0.00000
	0.3906	0.00000	0.00000	0.00000	0.00001	0.00001
	0	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00007	0.00006	0.00005	0.00026	0.00040
	12.79	8.10	1.27	3.08	0.00	0.35
	0.0010	**0.0006**	**0.0001**	**0.0001**	**0.0000**	**0.0001**

Table B-3. Estimates of numbers of marine mammals that could be struck by debris from missiles or targets: Additional FLEETEX.

Adults	Body Weight (kg)	Surface Area of Missile (m2) Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	11-100,000+	4.787	4.203	2.926	17.086	25.935
Sperm whale	15-48,000	4.787	4.203	2.926	17.086	25.935
Beaked Whales	2500	4.787	4.203	2.926	17.086	25.935
Killer whale	5000	4.787	4.203	2.926	17.086	25.935
Pilot whale	800	4.787	4.203	2.926	17.086	25.935
Risso's dolphin	300	4.787	4.203	2.926	17.086	25.935
Northern right whale dolphin	90	4.787	4.203	2.926	17.086	25.935
Bottlenose dolphin	200	4.787	4.203	2.926	17.086	25.935
White-sided dolphin	200	4.787	4.203	2.926	17.086	25.935
Common dolphin	75	4.787	4.203	2.926	17.086	25.935
Striped dolphin	125	4.787	4.203	2.926	17.086	25.935
Dall's porpoise	175	4.787	4.203	2.926	17.086	25.935
Harbor porpoise	64	4.787	4.203	2.926	17.086	25.935
California Sea Lion	200	4.787	4.203	2.926	17.086	25.935
Northern Fur Seal	150	4.787	4.203	2.926	17.086	25.935
Northern Elephant Seal	1000	4.787	4.203	2.926	17.086	25.935
Harbor Seal	65	4.787	4.203	2.926	17.086	25.935

Stratum 8

	Density	# animals Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.010889	0.00000	0.00000	0.00000	0.00000	0.00000
	0.035285	0.00000	0.00000	0.00000	0.00000	0.00000
	0.033638	0.00000	0.00000	0.00000	0.00000	0.00000
	0.003872	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.196324	0.00000	0.00000	0.00000	0.00000	0.00001
	0.353525	0.00000	0.00000	0.00000	0.00001	0.00001
	0.001038	0.00000	0.00000	0.00000	0.00000	0.00000
	0.123881	0.00000	0.00000	0.00000	0.00000	0.00000
	1.257492	0.00001	0.00001	0.00000	0.00002	0.00003
	0.055366	0.00000	0.00000	0.00000	0.00000	0.00000
	0.040641	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.493517	0.00000	0.00000	0.00000	0.00001	0.00001
	0.253685	0.00000	0.00000	0.00000	0.00000	0.00001
	0.069171	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
All Species		0.00001	0.00001	0.00001	0.00005	0.00008
No. of Missiles + Targets	**26.70**	13.50	4.73	8.48	0.00	0.00
Total Injury	**0.0003**	**0.0002**	**0.0001**	**0.0001**	**0.0000**	**0.0000**

Stratum 5

	Density	# animals Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.038473	0.00000	0.00000	0.00000	0.00000	0.00000
	0.012723	0.00000	0.00000	0.00000	0.00000	0.00000
	0.033638	0.00000	0.00000	0.00000	0.00000	0.00000
	0.003872	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.413388	0.00000	0.00000	0.00000	0.00001	0.00001
	1.076326	0.00001	0.00000	0.00000	0.00002	0.00003
	0.030424	0.00000	0.00000	0.00000	0.00000	0.00000
	0.311745	0.00000	0.00000	0.00000	0.00001	0.00001
	1.663017	0.00001	0.00001	0.00000	0.00003	0.00004
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.091298	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	1.585215	0.00001	0.00001	0.00000	0.00003	0.00004
	0.121345	0.00000	0.00000	0.00000	0.00000	0.00000
	0.211684	0.00000	0.00000	0.00000	0.00000	0.00001
	0.040920	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00003	0.00002	0.00002	0.00010	0.00015
	17.7525	6.75	3.47625	7.52625	0	0
	0.0004	**0.0002**	**0.0001**	**0.0001**	**0.0000**	**0.0000**

Surface area of each missile	2	2	2	2	2
Radius of missile	0.19	0.1715	0.1125	0.355	0.669
pi	3.1416	3.1416	3.1416	3.1416	3.1416
Height of missile	4.01	3.9	4.14	7.66	6.17
Surface area of missile	4.787	4.203	2.926	17.086	25.935

Assumptions:
- 25% of Phoenix/Standard-sized missiles land intact
- 50% of AltAir-sized missiles land intact
- 13 (current) + 4 (addn fleetex) of the targets contribute to debris (based on number of live wareheads in missiles)

Animals hit by debris	
Total missiles+Targets	46.425
Total Injured	**0.0008**
g(0)=	0.354
Total at surface	*0.0003*
Non-territorial waters	0.0002508
Territorial waters	4.175E-05

Stratum 6

	Density	# animals Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.056706	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.003872	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.351729	0.00000	0.00000	0.00000	0.00001	0.00001
	0.190383	0.00000	0.00000	0.00000	0.00000	0.00000
	0.058924	0.00000	0.00000	0.00000	0.00000	0.00000
	0.337042	0.00000	0.00000	0.00000	0.00001	0.00001
	7.834748	0.00004	0.00003	0.00002	0.00013	0.00020
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.103362	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	6.225061	0.00003	0.00003	0.00002	0.00011	0.00016
	0.044676	0.00000	0.00000	0.00000	0.00000	0.00000
	0.343189	0.00000	0.00000	0.00000	0.00001	0.00001
	0.248802	0.00000	0.00000	0.00000	0.00000	0.00001
All Species		0.00008	0.00007	0.00005	0.00027	0.00041
No. of Missiles + Targets	**0**	0	0	0	0	0
Total Injury	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

Stratum 4

	Density	# animals Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.056706	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.003872	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.351729	0.00000	0.00000	0.00000	0.00001	0.00001
	0.190383	0.00000	0.00000	0.00000	0.00000	0.00000
	0.058924	0.00000	0.00000	0.00000	0.00000	0.00000
	0.337042	0.00000	0.00000	0.00000	0.00001	0.00001
	7.834748	0.00004	0.00003	0.00002	0.00013	0.00020
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.103362	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	6.033193	0.00003	0.00003	0.00002	0.00010	0.00016
	0.034371	0.00000	0.00000	0.00000	0.00000	0.00000
	0.390567	0.00000	0.00000	0.00000	0.00001	0.00001
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00007	0.00006	0.00005	0.00026	0.00040
	1.9725	0.75	0.38625	0.83625	0	0
	0.0001	**0.0001**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

Table B-4. Estimates of numbers of marine mammals that could be struck by debris from missiles or targets: Nearshore Intercept.

Stratum 4 near shore where density is 5X rest of Stratum 4

		Surface Area of Missile (m2)						# animals				
Adults	Body Weight (kg)	Phoenix	Harpoon	AQM-37	Vandal	AltAir	Density	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	11-100,000+	4.787	4.203	2.926	17.086	25.935	0.05671	0.00000	0.00000	0.00000	0.00000	0.00001
Sperm whale	15-48,000	4.787	4.203	2.926	17.086	25.935	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Beaked Whales	2500	4.787	4.203	2.926	17.086	25.935	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Killer whale	5000	4.787	4.203	2.926	17.086	25.935	0.00387	0.00000	0.00000	0.00000	0.00000	0.00000
Pilot whale	800	4.787	4.203	2.926	17.086	25.935	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Risso's dolphin	300	4.787	4.203	2.926	17.086	25.935	0.35173	0.00001	0.00001	0.00001	0.00003	0.00005
Northern right whale dolphin	90	4.787	4.203	2.926	17.086	25.935	0.19038	0.00000	0.00000	0.00000	0.00002	0.00002
Bottlenose dolphin	200	4.787	4.203	2.926	17.086	25.935	0.05892	0.00000	0.00000	0.00000	0.00001	0.00001
White-sided dolphin	200	4.787	4.203	2.926	17.086	25.935	0.33704	0.00001	0.00001	0.00000	0.00003	0.00004
Common dolphin	75	4.787	4.203	2.926	17.086	25.935	7.83475	0.00019	0.00016	0.00011	0.00067	0.00102
Striped dolphin	125	4.787	4.203	2.926	17.086	25.935	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Dall's porpoise	175	4.787	4.203	2.926	17.086	25.935	0.10336	0.00000	0.00000	0.00000	0.00001	0.00001
Harbor porpoise	64	4.787	4.203	2.926	17.086	25.935	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
California Sea Lion	200	4.787	4.203	2.926	17.086	25.935	6.03319	0.00014	0.00013	0.00009	0.00052	0.00078
Northern Fur Seal	150	4.787	4.203	2.926	17.086	25.935	0.03437	0.00000	0.00000	0.00000	0.00000	0.00000
Northern Elephant Seal	1000	4.787	4.203	2.926	17.086	25.935	0.39057	0.00001	0.00001	0.00001	0.00003	0.00005
Harbor Seal	65	4.787	4.203	2.926	17.086	25.935	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
						All Species		0.00037	0.00032	0.00023	0.00132	0.00200
						No. of Missiles + Targets	**12.00**	6	6	0	0	0
						Total Injury	**0.0042**	**0.0022**	**0.0019**	**0.0000**	**0.0000**	**0.0000**

Surface area of ech missile	2	2	2	2	2
Radius of missile	0.19	0.1715	0.1125	0.355	0.669
pi	3.1416	3.1416	3.1416	3.1416	3.1416
Height of missile	4.01	3.9	4.14	7.66	6.17
Surface area of missile	4.787	4.203	2.926	17.086	25.935

Total targets and missiles	12.00
Total Injured	0.0042
g(0) =	0.354
Total at surface	**0.0015**
Non-territorial waters	*0.0000*
Territorial waters	0.0015

Table B-5. Estimates of numbers of marine mammals that could be struck by debris from missiles or targets: Theater Missile Defense.

Adults	Body Weight (kg)	Surface Area of Missile (m^2): Phoenix	Standard	AQM-37	Vandal	AltAir
Baleen whales	11-100,000+	4.787	4.203	2.926	2.926	25.935
Sperm whale	15-48,000	4.787	4.203	2.926	2.926	25.935
Beaked Whales	2500	4.787	4.203	2.926	2.926	25.935
Killer whale	5000	4.787	4.203	2.926	2.926	25.935
Pilot whale	800	4.787	4.203	2.926	2.926	25.935
Risso's dolphin	300	4.787	4.203	2.926	2.926	25.935
Northern right whale dolphin	90	4.787	4.203	2.926	2.926	25.935
Bottlenose dolphin	200	4.787	4.203	2.926	2.926	25.935
White-sided dolphin	200	4.787	4.203	2.926	2.926	25.935
Common dolphin	75	4.787	4.203	2.926	2.926	25.935
Striped dolphin	125	4.787	4.203	2.926	2.926	25.935
Dall's porpoise	175	4.787	4.203	2.926	2.926	25.935
Harbor porpoise	64	4.787	4.203	2.926	2.926	25.935
California Sea Lion	200	4.787	4.203	2.926	2.926	25.935
Northern Fur Seal	150	4.787	4.203	2.926	2.926	25.935
Northern Elephant Seal	1000	4.787	4.203	2.926	2.926	25.935
Harbor Seal	65	4.787	4.203	2.926	2.926	25.935

Stratum 8

	Density	# animals: Phoenix	Standard	AQM-37	Vandal	AltAir
	0.010889	0.00000	0.00000	0.00000	0.00000	0.00002
	0.035285	0.00000	0.00000	0.00000	0.00000	0.00007
	0.033638	0.00000	0.00000	0.00000	0.00000	0.00007
	0.003872	0.00000	0.00000	0.00000	0.00000	0.00001
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.196324	0.00001	0.00001	0.00001	0.00001	0.00041
	0.353525	0.00003	0.00002	0.00001	0.00001	0.00075
	0.001038	0.00000	0.00000	0.00000	0.00000	0.00000
	0.123881	0.00001	0.00001	0.00000	0.00000	0.00026
	1.257492	0.00009	0.00007	0.00003	0.00003	0.00266
	0.055366	0.00000	0.00000	0.00000	0.00000	0.00012
	0.040641	0.00000	0.00000	0.00000	0.00000	0.00009
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.493517	0.00004	0.00003	0.00001	0.00001	0.00104
	0.253685	0.00002	0.00001	0.00001	0.00001	0.00054
	0.069171	0.00000	0.00000	0.00000	0.00000	0.00015
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
All Species		0.00021	0.00016	0.00008	0.00008	0.00619
No. of Missiles + Targets	**8.55**	6.30	0.00	0.00	0.00	2.25
Total Injury	**0.0153**	**0.0013**	**0.0000**	**0.0000**	**0.0000**	**0.0139**

Stratum 5

Density	# animals: Phoenix	Standard	AQM-37	Vandal	AltAir
0.038473	0.00000	0.00000	0.00000	0.00000	0.00008
0.012723	0.00000	0.00000	0.00000	0.00000	0.00003
0.033638	0.00000	0.00000	0.00000	0.00000	0.00007
0.003872	0.00000	0.00000	0.00000	0.00000	0.00001
0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
0.413388	0.00003	0.00002	0.00001	0.00001	0.00087
1.076326	0.00008	0.00006	0.00003	0.00003	0.00227
0.030424	0.00000	0.00000	0.00000	0.00000	0.00006
0.311745	0.00002	0.00002	0.00001	0.00001	0.00066
1.663017	0.00012	0.00009	0.00004	0.00004	0.00351
0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
0.091298	0.00001	0.00001	0.00000	0.00000	0.00019
0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
1.585215	0.00011	0.00009	0.00004	0.00004	0.00335
0.121345	0.00001	0.00001	0.00000	0.00000	0.00026
0.211684	0.00002	0.00001	0.00001	0.00001	0.00045
0.040920	0.00000	0.00000	0.00000	0.00000	0.00009
	0.00041	0.00031	0.00015	0.00015	0.01191
4.68	2.50	0.00	0.00	0.00	2.18
0.0269	**0.0010**	**0.0000**	**0.0000**	**0.0000**	**0.0259**

Surface area of each missile					
Radius of missile	0.19	0.1715	0.1125	0.355	0.669
pi	3.1416	3.1416	3.1416	3.1416	3.1416
Height of missile	4.01	3.9	4.14	7.66	6.17
Surface area of missile	4.787	4.203	2.926	17.086	25.935

Assumptions:
- 25% of Phoenix/Standard-sized missiles land intact
- 50% of AltAir-sized missiles land intact
- 13 (current) + 4 (addn fleetex) of the targets contribute to debris (based on number of live wareheads in missiles)

Total Targets	13.51
Total animals	0.0450
g(0) =	0.354
Total at surface	**0.0159**
Non-territorial waters	0.0149
Territorial waters	0.0010

Stratum 6

	Density	# animals: Phoenix	Standard	AQM-37	Vandal	AltAir
	0.056706	0.00000	0.00000	0.00000	0.00000	0.00012
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.003872	0.00000	0.00000	0.00000	0.00000	0.00001
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.351729	0.00003	0.00002	0.00001	0.00001	0.00074
	0.190383	0.00001	0.00001	0.00001	0.00001	0.00040
	0.058924	0.00000	0.00000	0.00000	0.00000	0.00012
	0.337042	0.00002	0.00002	0.00001	0.00001	0.00071
	7.834748	0.00056	0.00043	0.00021	0.00021	0.01656
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.103362	0.00001	0.00001	0.00000	0.00000	0.00022
	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	6.225061	0.00045	0.00035	0.00017	0.00017	0.01315
	0.044676	0.00000	0.00000	0.00000	0.00000	0.00009
	0.343189	0.00002	0.00002	0.00001	0.00001	0.00073
	0.248802	0.00002	0.00001	0.00001	0.00001	0.00053
All Species		0.00114	0.00088	0.00043	0.00043	0.03338
No. of Missiles + Targets	**0.006**	0.000	0.000	0.000	0.000	0.006
Total Injury	**0.0002**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0002**

Stratum 4

Density	# animals: Phoenix	Standard	AQM-37	Vandal	AltAir
0.056706	0.00000	0.00000	0.00000	0.00000	0.00012
0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
0.003872	0.00000	0.00000	0.00000	0.00000	0.00001
0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
0.351729	0.00003	0.00002	0.00001	0.00001	0.00074
0.190383	0.00001	0.00001	0.00001	0.00001	0.00040
0.058924	0.00000	0.00000	0.00000	0.00000	0.00012
0.337042	0.00002	0.00002	0.00001	0.00001	0.00071
7.834748	0.00056	0.00043	0.00021	0.00021	0.01656
0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
0.103362	0.00001	0.00001	0.00000	0.00000	0.00022
0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
6.033193	0.00043	0.00033	0.00016	0.00016	0.01275
0.034371	0.00000	0.00000	0.00000	0.00000	0.00007
0.390567	0.00003	0.00002	0.00001	0.00001	0.00083
0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00111	0.00085	0.00041	0.00041	0.03253
0.28	0.20	0.00	0.00	0.00	0.08
0.0027	**0.0002**	**0.0000**	**0.0000**	**0.0000**	**0.0024**

Table B-6. Estimates of numbers of marine mammals that might be hit by CIWS rounds.

			Block 8		Block 5		Block 4		Block 6	
Adults	Body Weight (kg)	CIWS Round radius (m)	Density (# / km^2)	# animals	Density (# / km^2)	# animals	Density (# / km^2)	# animals	Density (# / km^2)	# animals
Baleen whales	11,000-100,000+	0.01	0.01089	0.00000	0.03847	0.00000000001	0.05671	0.000000000	0.05671	0.000000
Sperm whale	15,000-48,000	0.01	0.03528	0.00000	0.01272	0.00000000000	0.00000	0.000000000	0.00000	0.000000
Beaked Whales	2500	0.01	0.03364	0.00000	0.03364	0.00000000001	0.00000	0.000000000	0.00000	0.000000
Killer whale	5000	0.01	0.00387	0.00000	0.00387	0.00000000000	0.00387	0.000000000	0.00387	0.000000
Pilot whale	800	0.01	0.00000	0.00000	0.00000	0.00000000000	0.00000	0.000000000	0.00000	0.000000
Risso's dolphin	300	0.01	0.19632	0.00000	0.41339	0.00000000013	0.35173	0.000000000	0.35173	0.000000
Northern right whale dolphin	90	0.01	0.35353	0.00000	1.07633	0.00000000034	0.19038	0.000000000	0.19038	0.000000
Bottlenose dolphin	200	0.01	0.00104	0.00000	0.03042	0.00000000001	0.05892	0.000000000	0.05892	0.000000
White-sided dolphin	200	0.01	0.12388	0.00000	0.31175	0.00000000010	0.33704	0.000000000	0.33704	0.000000
Common dolphin	75	0.01	1.25749	0.00000	1.66302	0.00000000052	7.83475	0.000000002	7.83475	0.000000
Striped dolphin	125	0.01	0.05537	0.00000	0.00000	0.00000000000	0.00000	0.000000000	0.00000	0.000000
Dall's porpoise	175	0.01	0.04064	0.00000	0.09130	0.00000000003	0.10336	0.000000000	0.10336	0.000000
Harbor porpoise	64	0.01	0.00000	0.00000	0.00000	0.00000000000	0.00000	0.000000000	0.00000	0.000000
California Sea Lion	200	0.01	0.49352	0.00000	1.58522	0.00000000050	6.03319	0.000000002	6.22506	0.000000
Northern Fur Seal	150	0.01	0.25369	0.00000	0.12135	0.00000000004	0.03437	0.000000000	0.04468	0.000000
Northern Elephant Seal	1000	0.01	0.06917	0.00000	0.21168	0.00000000007	0.39057	0.000000000	0.34319	0.000000
Harbor Seal	65	0.01	0.00000	0.00000	0.04092	0.00000000001	0	0.000000000	0.24880	0.000000
		Number of animals/event		0.00000		0.00000		0.00000		0.000000
		Number of events		0.00		1500		1500		0
		Total animals injured		**0.0000**		**0.0000027**		**0.0000073**		**0.0000**

CIWS raduis in m 0.01

Total Targets	**3000**
Total animals in area	**0.00001**
g(0) all mar mamm	0.354
Animals at surface	**0.000004**
Territorial Waters	0.000003
Non Territorial Waters	*0.000001*

Assumptions: Only animals at the surface are injured.
Most activity at boundary between 4a and 4b (Strata 5 and 4).

Table B-7A. Estimates of numbers of marine mammals that are subjected to TTS from intact missiles and targets hitting the water: Animals below the surface during Current Operations.

Adults	Body Weight (kg)	Distance to which TTS might occur (m): Phoenix	Harpoon	AQM-37	Vandal	AltAir	1.00-g(0)
Baleen whales	11-100,000+	120	0	40	100	180	0.72189
Sperm whale	15-48,000	100	0	0	60	100	0.68000
Beaked Whales	2500	100	0	0	60	100	0.91405
Killer whale	5000	100	0	0	60	100	0.86890
Pilot whale	800	100	0	0	60	100	0.68510
Risso's dolphin	300	100	0	0	60	100	0.68510
Northern right whale dolphin	90	100	0	0	60	100	0.68510
Bottlenose dolphin	200	100	0	0	60	100	0.68510
White-sided dolphin	200	100	0	0	60	100	0.68510
Common dolphin	75	100	0	0	60	100	0.68510
Striped dolphin	125	100	0	0	60	100	0.68510
Dall's porpoise	175	100	0	0	60	100	0.78000
Harbor porpoise	64	100	0	0	60	100	0.70800
California Sea Lion	200	100	0	0	60	100	0.51626
Northern Fur Seal	150	100	0	0	60	100	0.51626
Northern Elephant Seal	1000	100	0	0	60	100	0.92094
Harbor Seal	65	100	0	0	60	100	0.74741

Stratum 8

Adults	Density	# animals: Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	0.01089	0.00036	0.00000	0.00004	0.00025	0.00080
Sperm whale	0.03528	0.00075	0.00000	0.00000	0.00027	0.00075
Beaked Whales	0.03364	0.00097	0.00000	0.00000	0.00035	0.00097
Killer whale	0.00387	0.00011	0.00000	0.00000	0.00004	0.00011
Pilot whale	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Risso's dolphin	0.19632	0.00423	0.00000	0.00000	0.00152	0.00423
Northern right whale dolphin	0.35353	0.00761	0.00000	0.00000	0.00274	0.00761
Bottlenose dolphin	0.00104	0.00002	0.00000	0.00000	0.00001	0.00002
White-sided dolphin	0.12388	0.00267	0.00000	0.00000	0.00096	0.00267
Common dolphin	1.25749	0.02707	0.00000	0.00000	0.00974	0.02707
Striped dolphin	0.05537	0.00119	0.00000	0.00000	0.00043	0.00119
Dall's porpoise	0.04064	0.00100	0.00000	0.00000	0.00036	0.00100
Harbor porpoise	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
California Sea Lion	0.49352	0.00800	0.00000	0.00000	0.00288	0.00800
Northern Fur Seal	0.25369	0.00411	0.00000	0.00000	0.00148	0.00411
Northern Elephant Seal	0.06917	0.00200	0.00000	0.00000	0.00072	0.00200
Harbor Seal	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
All Species		0.06008	0.00000	0.00004	0.02175	0.06052
No. of Missiles + Targets	**43.17**	24.25	7.75	3.17	8.00	0.00
Total Injury	**1.6310**	1.4569	0.0000	0.0001	0.1740	0.0000

Stratum 5

Adults	Density	# animals: Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	0.03847	0.00126	0.00000	0.00014	0.00087	0.00283
Sperm whale	0.01272	0.00027	0.00000	0.00000	0.00010	0.00027
Beaked Whales	0.03364	0.00097	0.00000	0.00000	0.00035	0.00097
Killer whale	0.00387	0.00011	0.00000	0.00000	0.00004	0.00011
Pilot whale	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Risso's dolphin	0.41339	0.00890	0.00000	0.00000	0.00320	0.00890
Northern right whale dolphin	1.07633	0.02317	0.00000	0.00000	0.00834	0.02317
Bottlenose dolphin	0.03042	0.00065	0.00000	0.00000	0.00024	0.00065
White-sided dolphin	0.31175	0.00671	0.00000	0.00000	0.00242	0.00671
Common dolphin	1.66302	0.03579	0.00000	0.00000	0.01289	0.03579
Striped dolphin	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Dall's porpoise	0.09130	0.00224	0.00000	0.00000	0.00081	0.00224
Harbor porpoise	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
California Sea Lion	1.58522	0.02571	0.00000	0.00000	0.00926	0.02571
Northern Fur Seal	0.12135	0.00197	0.00000	0.00000	0.00071	0.00197
Northern Elephant Seal	0.21168	0.00612	0.00000	0.00000	0.00220	0.00612
Harbor Seal	0.04092	0.00096	0.00000	0.00000	0.00035	0.00096
All Species		0.00000	0.00000	0.00014	0.04176	0.11639
No. of Missiles + Targets	**43.09**	21.60	9.22	9.47	0.00	2.80
Total Injury	**0.3272**	**0.0000**	**0.0000**	**0.0013**	**0.0000**	**0.3259**

Animals exposed to TTS	
Total Missiles and Targets	97.03
Total animals below surface	3.83
Territorial Waters	1.87
Non-territorial waters	*1.96*
Total animals at surface	0.20
Territorial Waters	0.07
Non-territorial waters	*0.14*
Total animals at and below surface	4.03
Territorial Waters	1.94
Non-territorial waters	*2.09*

Assumes that marine mammals are 50 m below surface

Stratum 6

	Density	# animals: Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.05671	0.00185	0.00000	0.00021	0.00129	0.00417
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00387	0.00011	0.00000	0.00000	0.00004	0.00011
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.35173	0.00757	0.00000	0.00000	0.00273	0.00757
	0.19038	0.00410	0.00000	0.00000	0.00148	0.00410
	0.05892	0.00127	0.00000	0.00000	0.00046	0.00127
	0.33704	0.00725	0.00000	0.00000	0.00261	0.00725
	7.83475	0.16863	0.00000	0.00000	0.06071	0.16863
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.10336	0.00253	0.00000	0.00000	0.00091	0.00253
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	6.22506	0.10096	0.00000	0.00000	0.03635	0.10096
	0.04468	0.00072	0.00000	0.00000	0.00026	0.00072
	0.34319	0.00993	0.00000	0.00000	0.00357	0.00993
	0.24880	0.00584	0.00000	0.00000	0.00210	0.00584
All Species		0.31077	0.00000	0.00021	0.11250	0.31308
No. of Missiles + Targets	**5.39**	2.70	1.15	1.18	0.00	0.35
Total Injury	**0.9489**	**0.8391**	**0.0000**	**0.0002**	**0.0000**	**0.1096**

Stratum 4

	Density	# animals: Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.05671	0.00185	0.00000	0.00021	0.00129	0.00417
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00387	0.00011	0.00000	0.00000	0.00004	0.00011
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.35173	0.00757	0.00000	0.00000	0.00273	0.00757
	0.19038	0.00410	0.00000	0.00000	0.00148	0.00410
	0.05892	0.00127	0.00000	0.00000	0.00046	0.00127
	0.33704	0.00725	0.00000	0.00000	0.00261	0.00725
	7.83475	0.16863	0.00000	0.00000	0.06071	0.16863
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.10336	0.00253	0.00000	0.00000	0.00091	0.00253
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	6.03319	0.09785	0.00000	0.00000	0.03523	0.09785
	0.03437	0.00056	0.00000	0.00000	0.00020	0.00056
	0.39057	0.01130	0.00000	0.00000	0.00407	0.01130
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
All Species		0.30302	0.00000	0.00021	0.10971	0.30533
No. of Missiles + Targets	**5.39**	2.70	1.15	1.18	0.00	0.35
Total Injury	**0.9253**	**0.8181**	**0.0000**	**0.0002**	**0.0000**	**0.1069**

Table B-7B. Estimates of numbers of marine mammals that are subjected to TTS from intact missiles and targets hitting the water: Animals at the surface during Current Operations.

		Distance (m)					
Adults	Body Weight (kg)	Phoenix	Harpoon	AQM-37	Vandal	AltAir	g(0)
Baleen whales	11-100,000+	40	10	20	40	80	0.27811
Sperm whale	15-48,000	20	5	10	21	40	0.32000
Beaked Whales	2500	20	5	10	21	40	0.08595
Killer whale	5000	20	5	10	21	40	0.13110
Pilot whale	800	20	5	10	21	40	0.31490
Risso's dolphin	300	20	5	10	21	40	0.31490
Northern right whale dolphin	90	20	5	10	21	40	0.31490
Bottlenose dolphin	200	20	5	10	21	40	0.31490
White-sided dolphin	200	20	5	10	21	40	0.31490
Common dolphin	75	20	5	10	21	40	0.31490
Striped dolphin	125	20	5	10	21	40	0.31490
Dall's porpoise	175	20	5	10	21	40	0.22000
Harbor porpoise	64	20	5	10	21	40	0.29200
California Sea Lion	200	20	5	10	21	40	0.48374
Northern Fur Seal	150	20	5	10	21	40	0.48374
Northern Elephant Seal	1000	20	5	10	21	40	0.07906
Harbor Seal	65	20	5	10	21	40	0.25259

Stratum 8

		# animals				
	Density	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	0.01089	0.00002	0.00000	0.00000	0.00002	0.00006
Sperm whale	0.03528	0.00001	0.00000	0.00000	0.00002	0.00006
Beaked Whales	0.03364	0.00000	0.00000	0.00000	0.00000	0.00001
Killer whale	0.00387	0.00000	0.00000	0.00000	0.00000	0.00000
Pilot whale	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Risso's dolphin	0.19632	0.00008	0.00000	0.00002	0.00009	0.00031
Northern right whale dolphin	0.35353	0.00014	0.00001	0.00003	0.00015	0.00056
Bottlenose dolphin	0.00104	0.00000	0.00000	0.00000	0.00000	0.00000
White-sided dolphin	0.12388	0.00005	0.00000	0.00001	0.00005	0.00020
Common dolphin	1.25749	0.00050	0.00003	0.00012	0.00055	0.00199
Striped dolphin	0.05537	0.00002	0.00000	0.00001	0.00002	0.00009
Dall's porpoise	0.04064	0.00001	0.00000	0.00000	0.00001	0.00004
Harbor porpoise	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
California Sea Lion	0.49352	0.00030	0.00002	0.00008	0.00033	0.00120
Northern Fur Seal	0.25369	0.00015	0.00001	0.00004	0.00017	0.00062
Northern Elephant Seal	0.06917	0.00001	0.00000	0.00000	0.00001	0.00003
Harbor Seal	0	0.00000	0.00000	0.00000	0.00000	0.00000
All Species		0.00129	0.00008	0.00032	0.00142	0.00517
No. of Missiles + Targets	**43.17**	24.25	7.75	3.17	8.00	0.00
Total Injury	**0.0444**	0.0313	0.0006	0.0010	0.0114	0.0000

Stratum 5

		# animals				
	Density	Phoenix	Harpoon	AQM-37	Vandal	AltAir
Baleen whales	0.03847	0.00005	0.00000	0.00001	0.00005	0.00022
Sperm whale	0.01272	0.00001	0.00000	0.00000	0.00001	0.00002
Beaked Whales	0.03364	0.00000	0.00000	0.00000	0.00000	0.00001
Killer whale	0.00387	0.00000	0.00000	0.00000	0.00000	0.00000
Pilot whale	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Risso's dolphin	0.41339	0.00016	0.00001	0.00004	0.00018	0.00065
Northern right whale dolphin	1.07633	0.00043	0.00003	0.00011	0.00047	0.00170
Bottlenose dolphin	0.03042	0.00001	0.00000	0.00000	0.00001	0.00005
White-sided dolphin	0.31175	0.00012	0.00001	0.00003	0.00014	0.00049
Common dolphin	1.66302	0.00066	0.00004	0.00016	0.00073	0.00263
Striped dolphin	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Dall's porpoise	0.09130	0.00003	0.00000	0.00001	0.00003	0.00010
Harbor porpoise	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
California Sea Lion	1.58522	0.00096	0.00006	0.00024	0.00106	0.00385
Northern Fur Seal	0.12135	0.00007	0.00000	0.00002	0.00008	0.00030
Northern Elephant Seal	0.21168	0.00002	0.00000	0.00001	0.00002	0.00008
Harbor Seal	0.04092	0.00001	0.00000	0.00000	0.00001	0.00005
All Species		0.00254	0.00016	0.00064	0.00280	0.01017
No. of Missiles + Targets	**43.09**	21.60	9.22	9.47	0.00	2.80
Total Injury	**0.0909**	**0.0549**	**0.0015**	**0.0060**	**0.0000**	**0.0285**

Animals exposed to TTS	
Total Missiles and Targets	97.03
Total animals at surface	0.20145
Territorial Waters	0.06618
Non-territorial waters	*0.13527*

Stratum 6

		# animals				
	Density	Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.05671	0.00008	0.00000	0.00002	0.00008	0.00032
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00387	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.35173	0.00014	0.00001	0.00003	0.00015	0.00056
	0.19038	0.00008	0.00000	0.00002	0.00008	0.00030
	0.05892	0.00002	0.00000	0.00001	0.00003	0.00009
	0.33704	0.00013	0.00001	0.00003	0.00015	0.00053
	7.83475	0.00310	0.00019	0.00078	0.00342	0.01240
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.10336	0.00003	0.00000	0.00001	0.00003	0.00011
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	6.22506	0.00378	0.00024	0.00095	0.00417	0.01514
	0.04468	0.00003	0.00000	0.00001	0.00003	0.00011
	0.34319	0.00003	0.00000	0.00001	0.00004	0.00014
	0.24880	0.00008	0.00000	0.00002	0.00009	0.00032
All Species		0.00750	0.00047	0.00188	0.00827	0.03002
No. of Missiles + Targets	**5.3858333**	2.7	1.15	1.18	0.00	0.35
Total Injury	**0.0335**	**0.0203**	**0.0005**	**0.0022**	**0.0000**	**0.0105**

Stratum 4

		# animals				
	Density	Phoenix	Harpoon	AQM-37	Vandal	AltAir
	0.05671	0.00008	0.00000	0.00002	0.00008	0.00032
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00387	0.00000	0.00000	0.00000	0.00000	0.00000
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.35173	0.00014	0.00001	0.00003	0.00015	0.00056
	0.19038	0.00008	0.00000	0.00002	0.00008	0.00030
	0.05892	0.00002	0.00000	0.00001	0.00003	0.00009
	0.33704	0.00013	0.00001	0.00003	0.00015	0.00053
	7.83475	0.00310	0.00019	0.00078	0.00342	0.01240
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	0.10336	0.00003	0.00000	0.00001	0.00003	0.00011
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
	6.03319	0.00367	0.00023	0.00092	0.00404	0.01467
	0.03437	0.00002	0.00000	0.00001	0.00002	0.00008
	0.39057	0.00004	0.00000	0.00001	0.00004	0.00016
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		0.00731	0.00046	0.00183	0.00805	0.02923
	5.39	2.70	1.15	1.18	0.00	0.35
	0.0326	**0.0197**	**0.0005**	**0.0022**	**0.0000**	**0.0102**

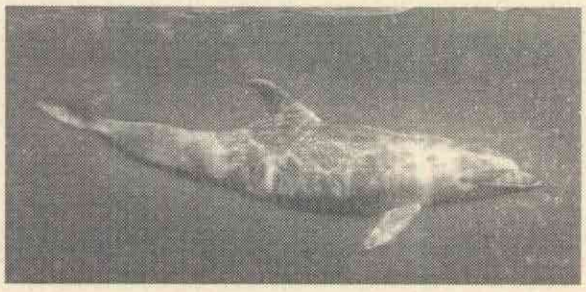
Table B-7C. Estimates of numbers of seals with their heads above water that may experience TTS due to CIWS gun firing.

			Block 8		Block 5		Block 4		Block 6	
Adults	Body Weight (kg)	Area of TTS for seals at sfc	Density (# / km^2)	# animals	Density (# / km^2)	# animals	Density (# / km^2)	# animals	Density (# / km^2)	# animals
Baleen whales	11,000-100,000+	0	0.010889	0.00000	0.038473	0.00000000000	0.05670614	0.000000000	0.05671	0.000000
Sperm whale	15,000-48,000	0	0.035285	0.00000	0.012723	0.00000000000	0	0.000000000	0.00000	0.000000
Beaked Whales	2500	0	0.033638	0.00000	0.033638	0.00000000000	0	0.000000000	0.00000	0.000000
Killer whale	5000	0	0.003872	0.00000	0.003872	0.00000000000	0.003871806	0.000000000	0.00387	0.000000
Pilot whale	800	0	0	0.00000	0	0.00000000000	0	0.000000000	0.00000	0.000000
Risso's dolphin	300	0	0.196324	0.00000	0.413388	0.00000000000	0.351728538	0.000000000	0.35173	0.000000
Northern right whale dolphin	90	0	0.353525	0.00000	1.076326	0.00000000000	0.190383326	0.000000000	0.19038	0.000000
Bottlenose dolphin	200	0	0.001038	0.00000	0.030424	0.00000000000	0.058924032	0.000000000	0.05892	0.000000
White-sided dolphin	200	0	0.123881	0.00000	0.311745	0.00000000000	0.33704196	0.000000000	0.33704	0.000000
Common dolphin	75	0	1.257492	0.00000	1.663017	0.00000000000	7.834747909	0.000000000	7.83475	0.000000
Striped dolphin	125	0	0.055366	0.00000	0	0.00000000000	0	0.000000000	0.00000	0.000000
Dall's porpoise	175	0	0.040641	0.00000	0.091298	0.00000000000	0.103362274	0.000000000	0.10336	0.000000
Harbor porpoise	64	0	0	0.00000	0	0.00000000000	0	0.000000000	0.00000	0.000000
California Sea Lion	200	464.3	0.493517	0.00023	1.585215	0.00073599620	6.033192796	0.002801138	6.22506	0.002890
Northern Fur Seal	150	464.3	0.253685	0.00012	0.121345	0.00005633920	0.034370678	0.000015958	0.04468	0.000021
Northern Elephant Seal	1000	464.3	0.069171	0.00003	0.211684	0.00009828215	0.390566703	0.000181335	0.34319	0.000159
Harbor Seal	65	464.3	0	0.00000	0.04092	0.00001899870	0	0.000000000	0.24880	0.000116
		Number of animals/event		0.00038		0.00091		0.00300		0.003186
		Number of events		0.00		15		15		0
		Total animals injured		**0.0000**		**0.0136442**		**0.0449765**		**0.0000**

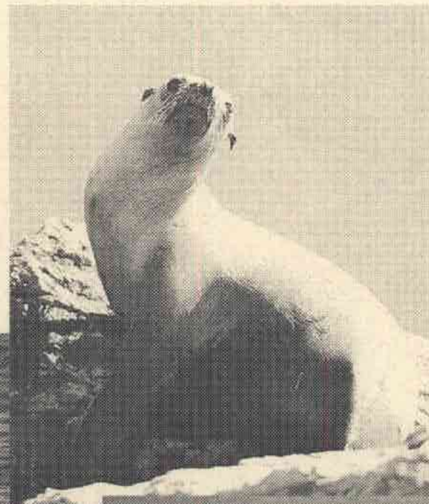
Width Affected	58.6
Distance from ship	7.9
Area affected m^2	464.3

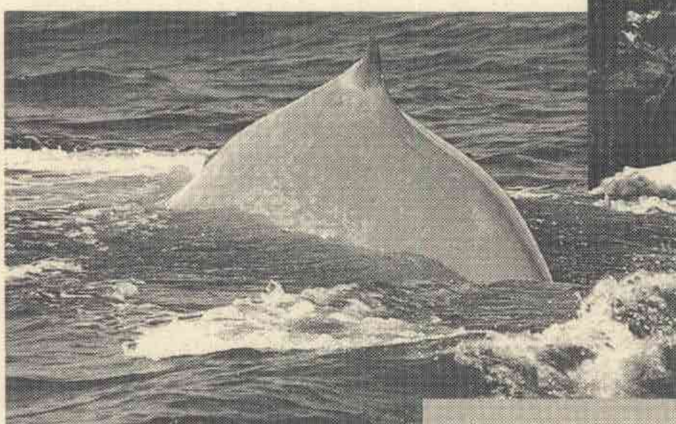
Total animals in area	**0.05862**
g(0) all mar mamm	0.354
Animals at surface	**0.02075**
Territorial Waters	0.01592
Non Territorial Waters	*0.00483*

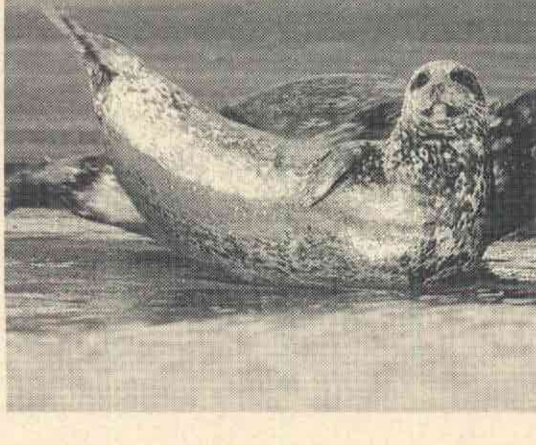
Assumptions: Only seals with heads above water experience TTS.
Most activity at boundary 4a and 4b (Strata 5 and 4).

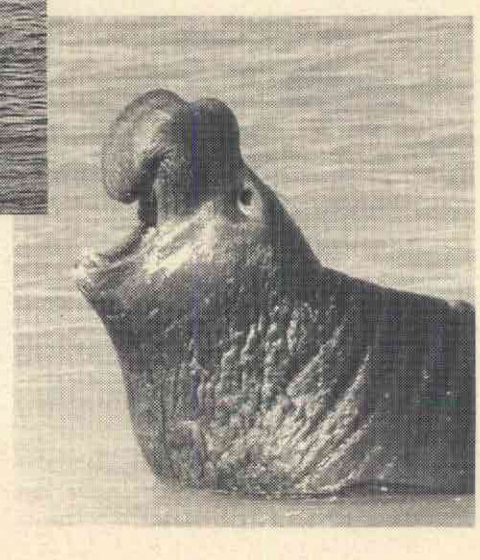


Appendix C









Appendix C

APPENDIX C
OVERVIEW OF AIRBORNE AND UNDERWATER ACOUSTICS

by

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INTRODUCTION

This appendix is taken from Chapter 3.3 of the EIS\OEIS and is included in the Marine Mammal Technical Report as a reference for those unfamiliar with the characteristics of in-air and underwater noise. Full citations for the literature cited in this appendix can be found in Chapter 7 of the EIS/OEIS.

Noise is defined as any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, diminishes the quality of the environment, or is otherwise annoying. Response to noise varies by the type and characteristics of the noise source, distance between source and receptor, receptor sensitivity, and time of day. Noise may be intermittent or continuous, steady or impulsive, and may be generated by stationary sources such as industrial plants or by transient sources such as automobiles and aircraft. Noise receptors can include humans as well as terrestrial and marine animals. Of specific concern to this analysis are potential noise effects on humans, marine mammals, birds, and fish (to the extent that noise introduced to the sea can affect catchability). Each receptor has higher or lower sensitivities to sounds of varying characteristics. Information specific to the noise receptors of concern (e.g., humans, marine mammals, etc.) is provided as appropriate.

Sound transmission characteristics are different for sounds in air versus sounds in water. Similarly, sound reception sensitivities vary for in-air sound and in-water sound. Therefore, this appendix is divided into two subsections: Airborne Noise and Underwater Noise.

AIRBORNE NOISE CHARACTERISTICS

Two distinct types of noise may result from aircraft operations. When aircraft fly slower than the speed of sound or subsonically, noise is produced by the aircraft's engine and by effects of aircraft movement through air. When an aircraft flies faster than the speed of sound, a sharply defined shock front is created, producing a distinct phenomenon called *overpressure*. Noise produced by this physical phenomenon is termed *impulse noise*. Thunder claps, noise from explosions, and sonic booms are examples of impulse noise. The characteristics of subsonic and supersonic noise are discussed below.

A - Subsonic Noise

The physical characteristics of noise (or sound) include its intensity, frequency, and duration. Sound is created by acoustic energy, which produces pressure waves that travel through a medium, like air or water, and are sensed by the eardrum. This may be likened to ripples in water that would be produced when a stone is dropped into it. As acoustic energy increases, the intensity or height of these pressure waves

increases, and the ear senses louder noise. The ear is capable of responding to an enormous range of sound levels, from that of a soft whisper to the roar of a rocket engine.

Units of Measurement

The range of sound levels that we are capable of hearing is very large. If the faintest sound level we can recognize (threshold of hearing) is assigned a value of one, then the highest level we are capable of hearing (threshold of pain), measured on the same scale, would have a value of ten million. In order to make this large range of values more meaningful, a logarithmic mathematical scale is used, the decibel [dB] scale. On this scale, the lowest level audible to humans is 0 dB and the threshold of pain is approximately 140 dB. The reference level for the decibel scale used to describe airborne sound is thus the threshold of hearing (for young adult listeners). In physical terms, this corresponds to a sound pressure of 20 micro Pascals (μPa). Atmospheric pressure is about 100,000 Pa.

Noise Measurement (weighting)

The normal human ear can detect sounds that range in frequency from about 20 cycles per second (Hz) to 15,000 Hz. However, all sounds throughout this range are not heard equally well. Figure C-1 shows the in-air hearing threshold curves (audiograms) for humans and two marine mammal species that can hear well in air as well as underwater. The human ear can be seen to be most sensitive at 1 to 4 kHz, whereas the sensitive band for the seal and sea lion extends upward to at least 10 kHz. However, at most frequencies the hearing threshold for these animals listening in air is 20 to 40 dB higher (less sensitive) than that for the human.

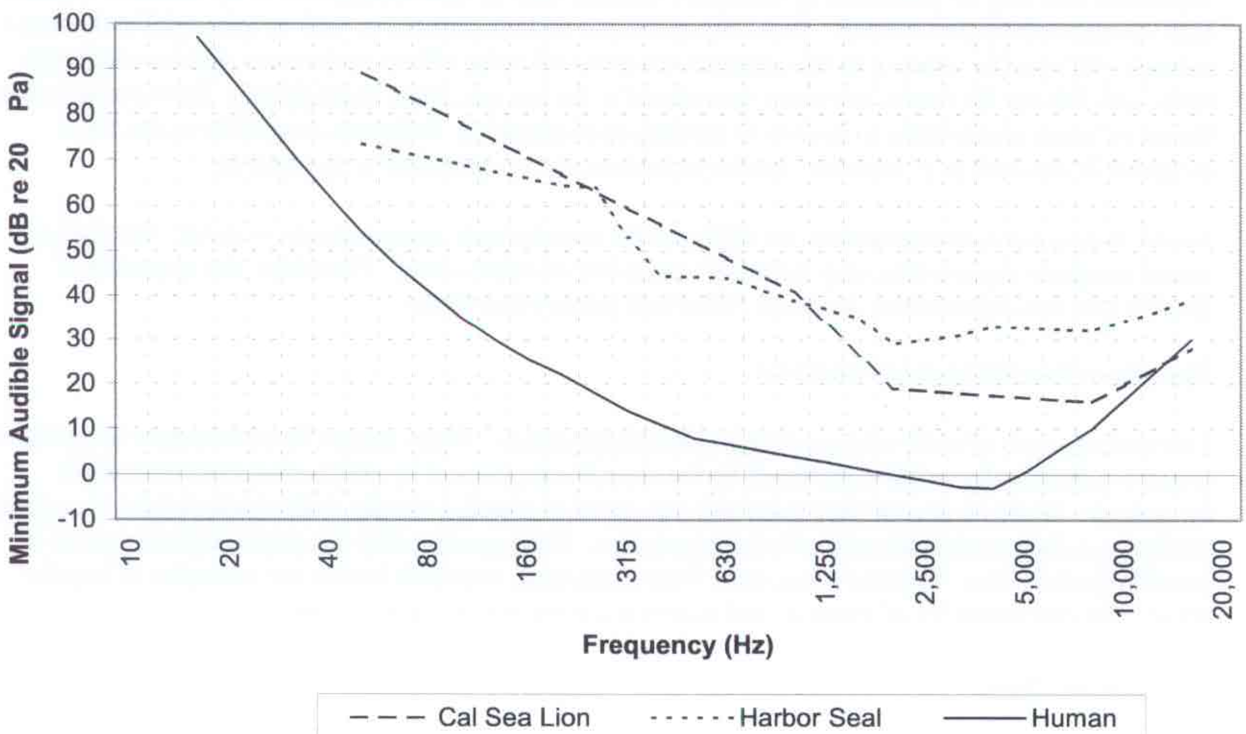

Figure C-1
Human and Marine Mammal In-Air Hearing Thresholds

Sound level meters have been developed to measure sound fields and to show the sound level as a number proportional to the overall sound pressure as measured on the logarithmic scale described previously. This is called the sound pressure level (SPL). It is often useful to have this meter provide a number that is directly related to the human sensation of loudness. Therefore, some sound meters are calibrated to emphasize frequencies in the 1 to 4 kHz range and to de-emphasize higher and especially lower frequencies to which humans are less sensitive. Sound level measurements obtained with these instruments are termed "A-weighted" (expressed in dBA). The A-weighting function is shown in Figure C-2. It can be seen to be closely based on the human hearing characteristic shown previously in Figure C-1. Because other animals are sensitive to a different range of frequencies, various other weighting protocols may be more appropriate when their specific hearing characteristics are known. Alternative measurement procedures such as C-weighting or flat-weighting (unweighted), which do not de-emphasize lower frequencies, may be more appropriate for various animal species such as baleen whales.

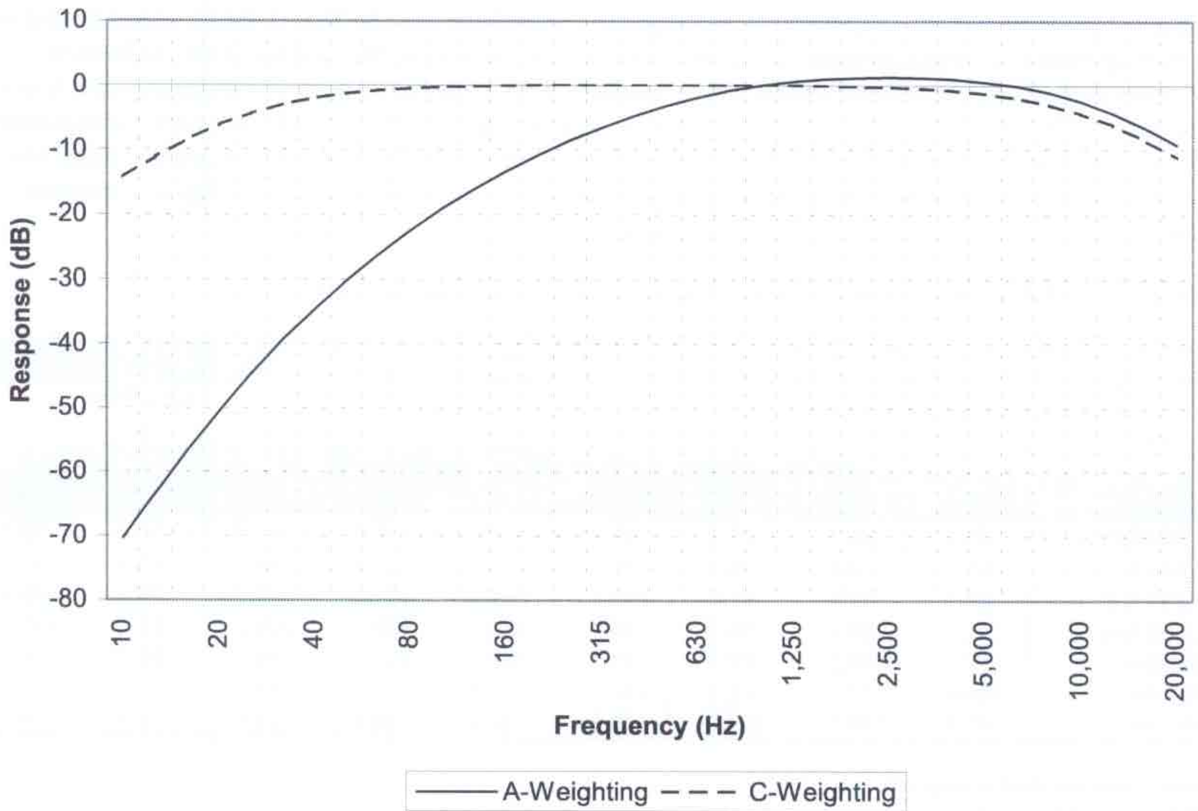

Figure C-2
Noise Weighting Characteristics

Although sound is often measured with instruments that record instantaneous sound levels in dB, the duration of a noise event and the number of times noise events occur are also important considerations in assessing noise impacts. With these measurements, sound levels for individual noise events and average sound levels, in decibels, over extended periods of hours, days, months, or years can be calculated (e.g., the daily day-night average sound level [L_{dn}] in dB).

Sound Exposure Level (Single Noise Event)

The sound exposure level (SEL) measurement provides a means of describing a single, time varying, noise event. It is useful for quantifying events such as an aircraft overflight, which includes the approach when noise levels are increasing, the instant when the aircraft is directly overhead with maximum noise level, and the period of time while the aircraft moves away with decreasing noise levels. SEL is a measure of the physical energy of a noise event, taking into account both intensity (loudness) and duration. SEL is based on the sounds received during the period while the level is above a specified threshold that is at least 10 dB below the maximum value measured during a noise event. SEL is usually determined on an A-weighted basis, and is defined as the constant sound level that provides the same amount of acoustic exposure in one second as the actual time-varying level for the exposure duration. It can also be expressed as the one-second averaged equivalent sound level (L_{eq} 1 sec).

Table C-1 provides a brief comparison of A-weighted, C-weighted, and flat SEL (F-SEL) values for military aircraft operating at various altitudes and power settings. By definition, SEL values are normalized to a reference time of one second and should not be confused with either the average or maximum noise levels associated with a specific event. There is no general relationship between the SEL value and the maximum decibel level measured during a noise event. By definition, SEL values exceed the maximum decibel level where noise events have durations greater than one second. For subsonic aircraft overflights, maximum noise levels are typically 5 to 7 dB below SEL values.

Table C-1. SEL Comparison for Select Department of Defense Aircraft

	P-3			F-4C			FA-18		
Power Setting; Speed (knots)	2000 ESHP 180			100% RPM 300			88% RPM 400		
	Sound Exposure Level (SEL) at Ground Level								
Altitude	A-SEL	C-SEL	F-SEL	A-SEL	C-SEL	F-SEL	A-SEL	C-SEL	F-SEL
2,500 feet	83.5	88.4	88.4	106.7	110.6	110.4	91.3	95.3	95.2
2,000 feet	85.6	90.0	90.0	109.0	112.7	112.6	93.7	97.4	97.3
1,600 feet	87.7	91.6	91.6	111.3	114.8	114.6	96.0	99.4	99.4
1,000 feet	91.7	94.7	94.7	115.7	118.7	118.7	100.2	103.2	103.2
500 feet	97.2	99.2	99.3	122.3	124.1	124.3	105.9	108.5	108.5
315 feet	100.6	102.2	102.2	126.7	127.5	127.7	109.3	111.7	111.8
200 feet	103.9	105.1	105.2	130.9	130.6	130.9	112.5	114.8	114.9

ESHP – effective shaft horsepower
RPM – revolutions per minute

Day-Night Average Sound Level

The day-night average sound level (L_{dn} or DNL) is the energy-averaged sound level measured over a 24-hour period, with a 10 dB penalty assigned to noise events occurring between 10:00 p.m. and 7:00 a.m. L_{dn} values are obtained by summation and averaging of SEL values for a given 24-hour period. L_{dn} is the preferred noise metric of the U.S. Department of Housing and Urban Development (HUD), Federal Aviation Administration (FAA), U.S. Environmental Protection Agency (USEPA), and Department of Defense (DoD) insofar as potential effects of airborne sound on humans are concerned.

People are constantly exposed to noise. Most people are exposed to average sound levels of 50-55 L_{dn} or higher for extended periods on a daily basis. Normal conversational speaking produces received sound

levels of approximately 60 dBA. Studies specifically conducted to determine noise impacts on various human activities show that about 90 percent of the population is not significantly bothered by outdoor average sound levels below 65 L_{dn} (FAA 1985).

L_{dn} considers noise levels of individual events that occur during a given period, the number of events, and the times (day or night) at which events occur. Since noise is measured on a logarithmic scale, louder noise events dominate the average. To illustrate this, consider a case in which only one aircraft flyover occurs in daytime during a 24-hour period, and creates a sound level of 100 dB for 30 seconds. During the remaining 23 hours, 59 minutes, and 30 seconds of the day, the ambient sound level is 50 dB. The calculated sound level for this 24-hour period is 65.5 L_{dn}. To continue the example, assume that ten such overflights occur during daytime hours during the next 24-hour period, with the same 50 dB ambient sound level during the remaining 23 hours and 55 minutes. The calculated sound level for this 24-hour period is 75.4 L_{dn}. Clearly, the averaging of noise over a given period does not suppress the louder single events.

In calculating L_{dn}, noise associated with aircraft operations is considered, and a 10 dB penalty is added to operations that occur between 10:00 p.m. and 7:00 a.m.; this time period is considered nighttime for the purposes of noise modeling. The 10 dB penalty is intended to compensate for generally lower background noise levels and increased human annoyance associated with noise events occurring between the hours of 10:00 p.m. and 7:00 a.m.

While L_{dn} does provide a single measure of overall noise, it does not provide specific information on the number of noise events or specific individual sound levels that occur. For example, as explained above, an L_{dn} of 65 dB could result from very few, but very loud events, or a large number of quieter events. Although it does not represent the sound level heard at any one particular time, it does represent total sound exposure. Scientific studies and social surveys have found L_{dn} to be the best measure to assess levels of human annoyance associated with all types of environmental noise. Therefore, its use is endorsed by the scientific community and governmental agencies (USEPA 1974; Federal Interagency Committee on Urban Noise [FICUN] 1980; Federal Interagency Committee on Noise [FICON] 1992).

California has taken the L_{dn} methodology one step further for characterizing noise around airfields. The State has adopted the Community Noise Equivalent Level (CNEL) scale, which is nearly identical to the L_{dn} scale. CNEL values include an additional 5 dB penalty for "evening" noise events occurring between 7:00 p.m. and 10:00 p.m. CNEL values are generally found to be approximately 1 dB greater than the same noise events characterized under L_{dn}.

Onset-Rate Adjusted Day-Night Average Sound Level

Aircraft operating at low altitude and in special use airspace generate noise levels different from other community noise environments. Overflights can be sporadic, which differs from most community environments where noise tends to be continuous or patterned.

Military overflight events also differ from typical community noise events because of the low altitude and high airspeed characteristics of military aircraft. These characteristics can result in a rate of increase in sound level (onset rate) of up to 30 dB per second. To account for the random and often sporadic nature of military flight activities, computer programs calculate noise levels created by these activities based on a monthly, rather than a daily, period. The L_{dn} metric is adjusted to account for the surprise, or startle effect of the onset rate of aircraft noise on humans. Onset rates above 30 dB per second require an 11 dB penalty because they may cause a startle associated with the rapid noise increase. Onset rates from 15 to 30 dB per second require an adjustment of 0 to 11 dB. Onset rates below 15 dB per second require no adjustment

because no startle is likely. The adjusted L_{dn} is designated as onset-rate adjusted monthly day-night average sound level (L_{dnmr}).

B - Supersonic Noise

A sonic boom is the noise a person, animal, or structure on the earth's surface receives when an aircraft or other type of air vehicle flies overhead faster than the speed of sound or supersonic. The speed of sound is referred to as Mach 1. This term, instead of a specific velocity, is used because the speed at which sound travels varies for different temperatures and pressures. For example, the speed of sound in air at standard atmospheric conditions at sea level is about 772 statute miles per hour (1,242 km per hour), or 1,132 feet per second (fps) (345 m per second). However, at an altitude of 25,000 feet (7,600 m), with its associated lower temperature and pressure, the speed of sound is reduced to 1,042 fps (318 m per second) (approximately 710 miles per hour [1,142 km per hour]). Thus, regardless of the absolute speed of the aircraft, when it reaches the speed of sound in the environment in which it is flying, its speed is Mach 1.

Air reacts like a fluid to supersonic objects. When an aircraft exceeds Mach 1, air molecules are pushed aside with great force forming a shock front much like a boat creates a bow wave. All aircraft generate two shock fronts. One is immediately in front of the aircraft; the other is immediately behind it. These shock fronts "push" a sharply defined surge in air pressure in front of them. When the shock fronts reach the ground, the result is a sonic boom. Actually, a sonic boom involves two very closely spaced impulses, one associated with each shock front. Most people on the ground cannot distinguish between the two and they are usually heard as a single sonic boom. However, the paired sonic booms created by vehicles the size and mass of the space shuttles are very distinguishable, and two distinct booms are easily heard.

Sonic booms differ from most other sounds because: (1) they are impulsive; (2) there is no warning of their impending occurrence; and (3) the peak levels of a sonic boom are higher than for most other types of outdoor noise. Although air vehicles exceeding Mach 1 always create a sonic boom, not all sonic booms are heard on the ground. As altitude increases, air temperature decreases and these layers of temperature change cause the shock front to be turned upward as it travels toward the ground. Depending on the altitude of the aircraft and the Mach number, the shock fronts of many sonic booms are bent upward sufficiently that they never reach the ground. This same phenomenon also acts to limit the width (area covered) of those sonic booms that do actually reach the ground.

Sonic booms are sensed by the human ear as an impulsive (sudden or sharp) sound because they are caused by a sudden change in air pressure. The change in air pressure associated with a sonic boom is generally a few pounds per square foot, which is about the same pressure change experienced riding an elevator down two or three floors. It is the rate of change—the sudden onset of the pressure change—that makes the sonic boom audible. The air pressure in excess of normal atmospheric pressure is referred to as *overpressure*. It is quantified on the ground by measuring the peak overpressure in pounds per square foot (psf) and the duration of the boom in milliseconds. The overpressure sensed is a function of the distance of the aircraft from the observer; the shape, weight, speed, and altitude of the aircraft; local atmospheric conditions; and location of the flight path relative to the surface. The maximum overpressures normally occur directly under the flight track of the aircraft and decrease as the slant range, or distance, from the aircraft to the receptor increases. Supersonic flights for a given aircraft type at high altitudes typically create sonic booms that have low overpressures but cover wide areas.

The noise associated with sonic booms is measured on a C-weighted scale (as shown previously in Figure C-2). C-weighting provides less attenuation at low frequencies than A-weighting. This is appropriate based

on the human auditory response to the low frequency sound pressures associated with high energy impulses (such as those generated by sonic booms).

C - Ambient Noise

Ambient noise is the background noise at a given location. Airborne ambient noise can vary considerably depending on location and other factors, such as wind speed, terrain features, vegetation, and the presence of distant natural or man-made noise sources.

In predicting human response to loud airborne noise sources, it is reasonable to assume that ambient background noise would have little or no effect on the calculated noise levels since the ambient levels would add insignificant fractions to calculated values. Therefore, ambient background noise is not considered in the noise calculations.

Ambient noise may have a more significant effect on prediction of marine mammal response to loud airborne noise sources. Marine mammals are exposed to a wide range of ambient sounds from the loud noise of nearby wave impacts to the quiet of remote areas during calm wind conditions. The ambient noise background on beaches is strongly influenced by surf noise. During high surf conditions pinnipeds may not hear an approaching aircraft until it is nearly overhead. The resulting rapid noise level increase may cause a panic response that normally would not occur for calm conditions when the approaching aircraft can be initially heard at longer ranges. Some examples of airborne noise levels in human and marine mammal habitat are given in Table C-2.

Table C-2. Representative Airborne Noise Levels

Source of Noise	dBA re 20 Pa
F-18 at 1,000 feet (Cruise Power)	98
Helicopter at 200 feet (UH-1N)	91
Car at 25 feet (60 mph) [1]	70 - 80
Light Traffic at 100 feet [1]	50 - 60
Quiet Residential (daytime) [1]	40 - 50
Quiet Residential (night) [1]	30 - 40
Wilderness Area [1]	20 - 30
Offshore (low sea state) [2]	40 - 50
Surf [2]	60 - 70

[1] Kinsler et al. 1982.
[2] U.S. Coast Guard 1960.

D - Additional Considerations

It should be noted that the characteristics of subsonic noise, which is measured on an A-weighted scale, and supersonic noise, which is measured on a C-weighted scale, are different. Therefore, each is calculated separately, and it would be incorrect to add the two values together. Nevertheless, both subsonic and supersonic noises occur in the Point Mugu Sea Range. Together, they form the cumulative acoustic environment in the region.

SOUND TRANSMISSION THROUGH THE AIR-WATER INTERFACE

Many of the sound sources considered in this EIS are airborne vehicles, but a significant portion of the concern about noise impacts involves marine animals at or below the surface of the water. Thus, transmission of airborne sound into the ocean is a significant consideration. This subsection describes some basic characteristics of air-to-water transmission of sound for both subsonic and supersonic sources.

A - Subsonic Sources

Sound is transmitted from an airborne source to a receiver underwater by four principal means: (1) a direct path, refracted upon passing through the interface; (2) direct-refracted paths reflected from the bottom in shallow water; (3) lateral (evanescent) transmission through the interface from the airborne sound field directly above; and (4) scattering from interface roughness due to wave motion.

Several papers are available in the literature concerning transmission of sound from air into water. Urick (1972) presents a discussion of the effect and reports data showing the difference in the underwater signature of an aircraft overflight for deep and shallow conditions. He includes analytic solutions for both the direct and lateral transmission paths and presents a comparison of the contributions of these paths for near-surface receivers. Young (1973) presents an analysis which, while directed at deep-water applications, derived an equivalent dipole underwater source for an aircraft overflight that can be used for direct path underwater received level estimates. A detailed description of air-water sound transmission is given in Richardson et al. (1995). The following is a short summary of the principal features.

Figure C-3 shows the general characteristics of sound transmission through the air-water interface. Sound from an elevated source in air is refracted upon transmission into water because of the difference in sound speeds in the two media (a ratio of about 0.23). Because of this difference, the direct sound path is totally reflected for grazing angles less than 77°, i.e., if the sound reaches the surface at an angle more than 13° from vertical. For smaller grazing angles, sound reaches an underwater observation point only by scattering from wave crests on the surface, by non-acoustic (lateral) pressure transmission from the surface, and from bottom reflections in shallow water. As a result, most of the acoustic energy transmitted into the water from a source in air arrives through a cone with a 26° apex angle extending vertically downward from the airborne source. For a moving source, the intersection of this cone with the surface traces a "footprint" directly beneath the path of the source, with the width of the footprint being a function of the altitude of the source. To a first approximation, it is only the sound transmitted within this footprint that can reach an underwater location by a direct-refracted path. Because of the large difference in the acoustic properties of water and air, the pressure field is actually doubled at the surface of the water, resulting in a 6 dB increase in pressure level at the surface. Within the direct-refracted cone, the in-air sound transmission paths are affected both by geometric spreading and by the effects of refraction.

In shallow water within the direct transmission cone, the directly transmitted sound energy is generally greater than the energy contribution from bottom reflected paths. At horizontal distances greater than the water depth, the energy transmitted by reflected paths becomes dominant, especially in shallow water. The ratio of direct to reverberant energy depends on the bottom properties. For hard bottom conditions the reverberant field persists for longer ranges than the direct field. However, with increasing horizontal distance from the airborne source, underwater sound diminishes more rapidly than does the airborne sound.

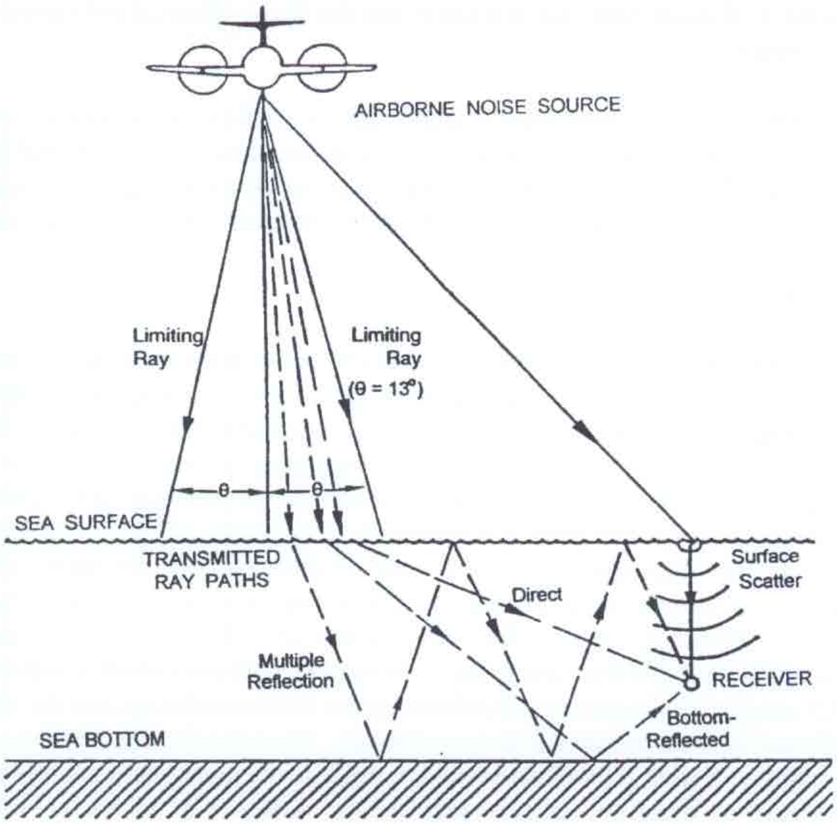

Figure C-3
Characteristics of Sound Transmission Through Air-Water Interface

Near the surface, the laterally transmitted pressure from the airborne sound is transmitted hydrostatically underwater. Beyond the direct transmission cone this component can produce higher levels than the underwater-refracted wave. However, the lateral component is very dependent on frequency and thus on acoustic wavelength. The level received underwater is 20 dB lower than the airborne sound level at a depth equal to 0.4 wavelength.

For this application, it is necessary to have an analytical model to predict the total acoustic exposure level experienced by marine mammals near the surface and at depth near the path of an aircraft overflight. Malme and Smith (1988) described a model to calculate the acoustic energy at an underwater receiver in shallow water, including the acoustic contributions of both the direct sound field (Urick 1972) and a depth--averaged reverberant sound field (Smith 1974).

In the present application, the Urick (1972) analysis for the lateral wave field was also included to predict this contribution. The paths of most concern for this application are the direct-refracted path and the lateral path. These paths will likely determine the highest sound level received by mammals located nearly directly below a passing airborne source and mammals located near the surface, but at some distance away from the source track. In shallow areas near shore, bottom-reflected acoustic energy will

also contribute to the total noise field, but it is likely that the direct-refracted and lateral paths will make the dominant contributions.[1]

For a passing airborne source, received level at and below the surface diminishes with increasing source altitude, but the duration of exposure increases. The maximum received levels at and below the surface are inversely proportional to source altitude, but total noise energy exposure is inversely proportional to the product of source altitude and speed because of the link between altitude and duration of exposure.

B - Supersonic Sources

The sonic boom footprint produced by a supersonic aircraft in level flight at constant speed traces a hyperbola on the sea surface. The apex of the hyperbola moves at the same speed and direction as the aircraft with the outlying arms of the hyperbola traveling at increasing oblique angles and slower speeds until the boom shock wave dissipates into a sonically-propagating pressure wave at large distances from the flight path. The highest boom overpressures at the water surface are produced directly below the aircraft track. In this region the pressure-time pattern is described as an "N-wave" because of its typical shape. The peak shock pressure and the time duration of the N-wave are determined by the aircraft size, shape, speed, and altitude. The incidence angle of the N-wave on the water surface is determined by the aircraft speed; i.e., for Mach 2 the incidence angle is 45°. Thus for aircraft in level flight at speed less than about Mach 4.3, the N-wave is totally reflected from the surface. Dives and other maneuvers at supersonic speeds of less than Mach 4.3 can generate N-waves at incidence angles that are refracted into the water, but the water source regions affected by these transient events are limited. Since the aircraft, missiles, and targets used in range activities generally operate at less than Mach 4.3, sonic boom penetration into the water from these sources occurs primarily by lateral (evanescent) propagation. Analyses by Sawyers (1968) and Cook (1969) have shown that the attenuation rate (penetration) of the boom pressure wave is related to the size, altitude and speed of the source vehicle. The attenuation of the N-wave is not related to the length of the signature in the simple way that the lateral wave penetration from subsonic sources is related to the dominant wavelength of their signature.

UNDERWATER NOISE CHARACTERISTICS

Many of the general characteristics of sound and its measurement were discussed in the introduction to airborne noise characteristics. This section expands on this introduction to summarize the properties of underwater noise that are relevant to understanding the effects of noise produced by range activities on the underwater marine environment in the Point Mugu area. Since the effects of underwater noise on human habitat is not an issue (except perhaps for divers), the primary environmental concern is the potential impact on marine mammals.

A - Units of Measurement

The reference level for airborne sound is 20 μPa, consistent with the minimum level detectable by humans. For underwater sound, a reference level of 1 μPa is used because this provides a more convenient reference and because a reference based on the threshold of human hearing in air is irrelevant. For this reason, as well as the different propagation properties of air and water, it is not meaningful to compare the levels of sound

[1] The bottom-reflected reverberant sound field section of this model for nearshore applications requires detailed knowledge of bottom slope and bottom composition. In view of the requirements of this application, this level of detail is not appropriate and the reflected path subroutine was not used.

received in air (measured in dB re 20 μPa) and in water (in dB re 1 μPa) without adding the 26 dB correction factor to the airborne sound levels.

B - Source Characteristics

The most significant range-related sources of underwater noise operating on the Sea Range are the ships used in Fleet Exercises (FLEETEX). Because of their slow speed compared to most of the airborne sources considered in the last section, they can be considered to be continuous sound sources. The primary underwater transient sound sources are sonars, torpedo missile launches, and water surface impacts from missiles and falling debris. All sources are subsonic or stationary in water. While supersonic underwater shock waves are produced at short ranges by underwater explosions, no sources operate at supersonic speeds in water.

C - Underwater Sound Transmission

Airborne sources transmit most of their acoustic energy to the surface by direct paths which attenuate sound energy by spherical divergence (spreading) and molecular absorption. For sound propagating along oblique paths relative to the ground plane, there may also be attenuation (or amplification) by refraction (bending) from sound speed gradients caused by wind and temperature changes with altitude. There may also be multipath transmission caused by convergence of several refracted and reflected sound rays, but this is generally not important for air-to-ground transmission. However, for underwater sound, refracted and multipath transmission is often more important than direct path transmission, particularly for high-power sound sources capable of transmitting sound energy to large distances.

Sound transmission from a surface ship to a shallow receiver in tropical and mid-latitude deep water areas is often enhanced by a surface layer sound channel. This channel is produced when a mixed isothermal surface layer is developed by wave action. An upward refracting sound gradient, produced by the pressure difference within the layer, traps a significant amount of the sound energy within the layer. (Sound travels faster with increasing depth.) This results in cylindrical rather than spherical spreading. This effect is particularly observable at high frequencies where the sound wavelengths are short compared to the layer depth. When the mixed layer is thin or not well defined, the underlying thermocline may extend toward the surface resulting in downward refraction at all frequencies and a significant increase in transmission loss at shorter ranges where bottom reflected sound energy is normally less than the directly transmitted sound component.

In shallow water areas sound is trapped by reflection between the surface and bottom interfaces. This often results in higher transmission loss than in deep water because of the loss that occurs with each reflection, especially from soft or rough bottom material. However, in areas with a highly reflective bottom, the transmission loss may be less than in deep water areas since cylindrical spreading may occur.

The many interacting variables involved in prediction of underwater transmission loss have led to the development of analytical and computer models. One or more of these models are used in analyzing the potential impact of the underwater noise sources in the range areas.

D - Underwater Ambient Noise

Above 500 Hz, deep ocean ambient noise is produced primarily by wind and sea state conditions. Below 500 Hz, the ambient noise levels are strongly related to ship traffic, both near and far. In shallow water near continents and islands, surf noise is also a significant factor. Wenz (1962) and Urick (1983) are among

many contributors to the literature on underwater ambient noise. Figure C-4, based on these two sources, was adapted by Malme et al. (1989) to show ambient noise spectra in 1/3 octave bands for a range of sea state and ship traffic conditions.

Wind

On a 1/3-octave basis, wind-related ambient noise in shallow water tends to peak at about 1 kHz (see Figure C-4). Levels in 1/3 octave bands generally decrease at a rate of 3-4 dB per octave at progressively higher frequencies and at about 6 dB per octave at progressively lower frequencies. Sound levels increase at a rate of 5-6 dB per doubling of wind speed. Maximum 1/3-octave band levels of about 95 dB referenced to 1 µPa are frequently observed at about 1 kHz for sustained winds of 34-40 knots (63-74 km per hour) and about 82 dB (also at 1 kHz) when the winds are in the 7-10 knot (13-19 km per hour) range. Since ambient noise related to wind is caused primarily by wave action and spray, the wind related noise component is strongly dependent on wind duration and fetch as well as water depth, bottom topography and proximity to topographic features such as islands and shore. A sea state scale which is related to sea surface conditions as a function of wind conditions is commonly used in categorizing wind-related ambient noise. The curves for wind-related ambient noise shown in Figure C-4 are reasonable averages, although relatively large departures from these curves can be experienced depending on site location and other factors such as bottom topography and proximity to island or land features.

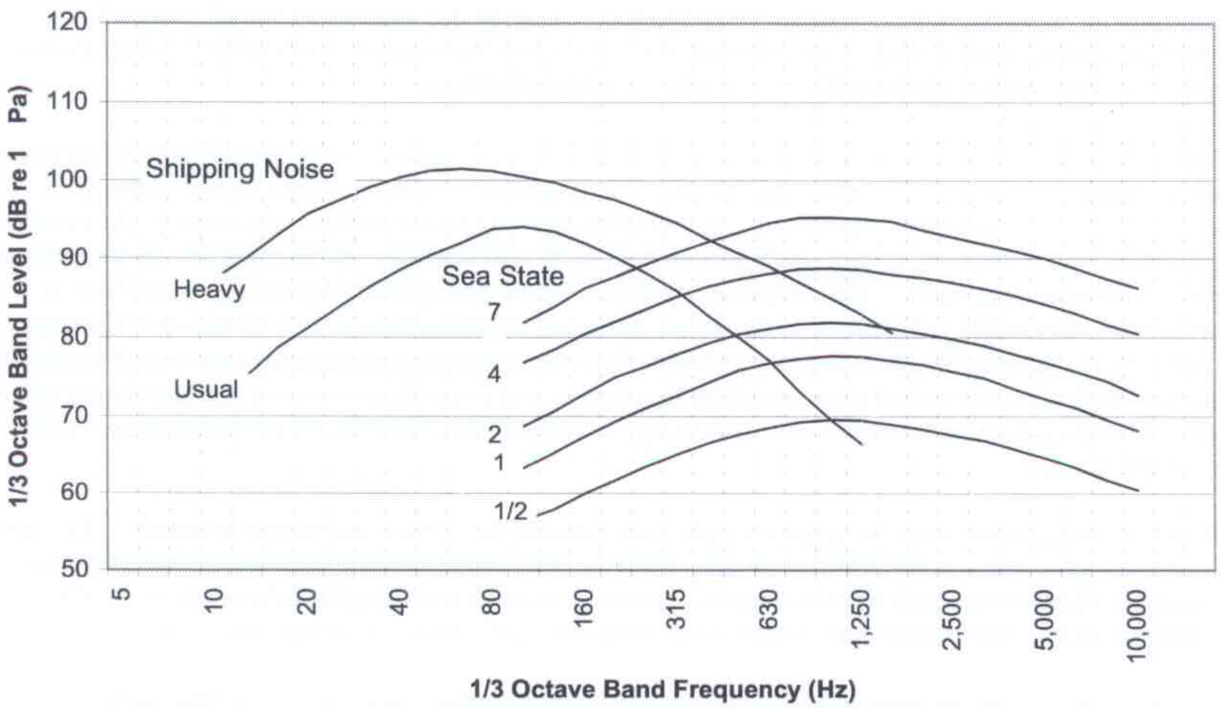

Figure C-4
Underwater Ambient Noise

Surf noise

Very few data have been published relating specifically to local noise due to surf in nearshore areas along mainland and island coasts. Wilson et al. (1985) present underwater noise levels for wind-driven surf along the exposed Monterey Bay coast, as measured at a variety of distances from the surf zone.

Wind conditions varied from 25-35 knots (46-65 km per hour). They vary from 110-120 dB in the 100-1,000 Hz band at a distance of 650 feet (200 m) from the surf zone, down to levels of 96-103 dB in the same band 4.6 NM (8.5 km) from the surf zone. Assuming that these levels are also representative near shorelines in the Point Mugu area, surf noise in the 100-500 Hz band will be 15-30 dB above that due to wind-related noise in the open ocean under similar wind speed conditions.

Distant shipping

The presence of a relatively constant low frequency component in ambient noise within the 10-200 Hz band has been observed for many years and has been related to distant ship traffic as summarized by Wenz (1962) and Urick (1983). Low frequency energy radiated primarily by cavitating propellers and by engine excitation of the ship hull is propagated efficiently in the deep ocean to distances of 100 NM (1,900 km) or more. Higher frequencies do not propagate well to these distances due to acoustic absorption. Also, high frequency sounds radiated by relatively nearby vessels will frequently be masked by local wind-related noise. Thus, distant shipping contributes little or no noise at high frequency. Distant ship-generated low frequency noise incurs more attenuation when it propagates across continental shelf regions and into shallow nearshore areas than occurs in the deep ocean.

Figure C-4 also provides two curves which approximate the upper bounds of distant ship traffic noise. The upper curve represents noise at sites exposed to heavily used shipping lanes. The lower curve represents moderate or distant shipping noise as measured in shallow water. As shown, highest observed ambient noise levels for these two categories are 102 dB and 94 dB, respectively, in the 60-100 Hz frequency range. In shallow water the received noise from distant ship traffic can be as much as 10 dB below the lower curve given in Figure C-4, depending on site location on the continental shelf. In fact, some nearshore areas can be effectively shielded from this low frequency component of shipping noise due to sound propagation loss effects.

Note that the shipping noise curves shown in Figure C-4 show typical received levels attributable to *distant* shipping. Considerably higher levels can be received when a ship is present within a few miles.